ESSER III Expenditure Plan

Local Educational Agency (LEA) Name	Contact Name and Title	Email and Phone
Nord Country School	Kathy Dahlgren Principal/Superintendent	kdahlgren@nordk8.org 530-891-3138

School districts, county offices of education, or charter schools, collectively known as LEAs, that receive Elementary and Secondary School Emergency Relief (ESSER) funds under the American Rescue Plan Act, referred to as ESSER III funds, are required to develop a plan for how they will use their ESSER III funds. In the plan, an LEA must explain how it intends to use its ESSER III funds to address students' academic, social, emotional, and mental health needs, as well as any opportunity gaps that existed before, and were worsened by, the COVID-19 pandemic. An LEA may also use its ESSER III funds in other ways, as detailed in the Fiscal Requirements section of the Instructions. In developing the plan, the LEA has flexibility to include community input and/or actions included in other planning documents, such as the Local Control and Accountability Plan (LCAP), provided that the input and actions are relevant to the LEA's Plan to support students.

For more information please see the Instructions.

Other LEA Plans Referenced in this Plan

Plan Title	Where the Plan May Be Accessed
2021-2022 Local Control Accountability Plan (LCAP)	http://www.nordcountryschool.org/uploads/5/2/3/3/5233925/2021_merged_lcap.pdf
Expanded Learning Opportunities Grant (ELO)	http://www.nordcountryschool.org/uploads/5/2/3/3/5233925/2021_expanded_learning_opportunities_grant_plan_nord_country_school_20210517.pdf

Summary of Planned ESSER III Expenditures

Below is a summary of the ESSER III funds received by the LEA and how the LEA intends to expend these funds in support of students.

Total ESSER III funds received by the LEA
$192,867

Plan Section	Total Planned ESSER III
Strategies for Continuous and Safe In-Person Learning	$129,292
Addressing Lost Instructional Time (a minimum of 20 percent of the LEAs ESSER III funds)	$63,575
Use of Any Remaining Funds	0

Total ESSER III funds included in this plan
$192,867

Community Engagement

An LEA's decisions about how to use its ESSER III funds will directly impact the students, families, and the local community. The following is a description of how the LEA meaningfully consulted with its community members in determining the prevention and mitigation strategies, strategies to address the academic impact of lost instructional time, and any other strategies or activities to be implemented by the LEA. In developing the plan, the LEA has flexibility to include input received from community members during the development of other LEA Plans, such as the LCAP, provided that the input is relevant to the development of the LEA's ESSER III Expenditure Plan.

For specific requirements, including a list of the community members that an LEA is required to consult with, please see the Community Engagement section of the Instructions.

A description of the efforts made by the LEA to meaningfully consult with its required community members and the opportunities provided by the LEA for public input in the development of the plan.

Nord Country School has prioritized community engagement in supporting a plan to use the ESSR III funds. The action items are also rooted in current research and have been presented to the community for input and guidance. The plan is an extension of the 2021-2022 Local Control and Accountability Plan (LCAP) and the Expanded Opportunities Grant (ELO), all of which seek to support learners through a Multi-Tiered Systems of Support (MTSS). In a resource utilized by the National Center on Intensive Intervention (2020), the book Essentials of Intervention highlights and justifies the importance of the MTSS structure (Edmonds, Ghandi & Danielson, 2020).

All stakeholder groups had opportunities to review data, provide input, and share their thoughts in the plan's development. Throughout the year, stakeholders had several opportunities for engagement during PTO, staff, board, and school site council meetings. Based on the information gathered from those meetings, in addition to data collected from Spring 2021 parent and student surveys, the school prioritized a list of needs for all COVID-19 funds from both the state and federal government.

ESSER III funds are being used to support all students in reducing learning loss, providing a safe and healthy school environment, supporting student social and emotional well being, and providing increased academic support for students who are struggling. The plan will allow the school to use funds received to implement additional learning supports for all students. Additionally, the plan targets those who are identified as being socio-economically disadvantaged, homeless/foster youth, English Learners (ELs), struggling academically, and/or in need of additional social and emotional support/strategies. Most of the above elements fall within the greater scope of our LCAP and ELO, and all plans noted in this plan are guided by the MTSS framework.

A description of how the development of the plan was influenced by community input.

The Nord school community reflects diverse groups, including those who are identified as low socioeconomic status (SES), English Learners (ELs), staff or community members who serve as homeless/foster advocates, and individuals involved with our SELPA. All school community individuals--including parents--were invited to attend meetings and give input to the development of the plan. Input that was gathered during staff meetings, LCAP, school site council, and parent-teacher organization meetings reflects how the ESSER III plan was influenced by community input.

Additionally, surveys were administered. Staff, parent/family and student surveys were conducted in March 2021.

Data from these surveys and meetings indicated that top priorities were to provide increased small group/one-on-one instruction, supports such as counseling and social-emotional learning, and staff development in the areas of accelerating learning and effectively closing learning gaps. These priorities led to further conversations during meetings with staff, administration, the governing board and parents.

The stakeholder feedback was developed into an overarching plan for coordinating funding sources, which was reviewed by the Board of Directors in April 2021 for the ELO Plan and again in September 2021 for the ESSER III plan. The culmination of this process resulted in the Board's approval of the ESSER III plan at a board meeting held on October 27th, 2021.

Actions and Expenditures to Address Student Needs

The following is the LEA’s plan for using its ESSER III funds to meet students’ academic, social, emotional, and mental health needs, as well as how the LEA will address the opportunity gaps that existed before, and were exacerbated by, the COVID-19 pandemic. In developing the plan, the LEA has the flexibility to include actions described in existing plans, including the LCAP and/or Expanded Learning Opportunity (ELO) Grant Plan, to the extent that the action(s) address the requirements of the ESSER III Expenditure Plan.
For specific requirements, please refer to the Actions and Expenditures to Address Student Needs section of the Instructions.

Strategies for Continuous and Safe In-Person Learning

A description of how the LEA will use funds to continuously and safely operate schools for in-person learning in a way that reduces or prevents the spread of the COVID-19 virus.

Total ESSER III funds being used to implement strategies for continuous and safe in-person learning
$129,292

Plan Alignment (if applicable)	Action Title	Action Description	Planned ESSER III Funded Expenditures
LCAP Goal #2	COVID-19 Safety Supplies	Provide a safe, clean environment for staff and students so that in-person instruction may occur to the greatest extent possible. Includes the purchase of materials and supplies needed to prevent the spread of COVID-19 on campus as well as any other materials and supplies deemed necessary by the administration	$11,092
ELO	Staff expansion	Hire new staff to focus on increasing and improving learning through assessment, assisting with the board-adopted safety plan, providing differentiated instructional support, supporting/supervising expanded intervention staff, and delivering training and materials to teachers (funded with ESSER II and ESSER III funds over two years)	$83,200
LCAP Goal #2, ELO	Increase social and emotional support	Contract with another school to share the services of a School Counselor (funded with ELO and ESSER III funds over two years)	$35,000

Addressing the Impact of Lost Instructional Time

A description of how the LEA will use funds to address the academic impact of lost instructional time.

Total ESSER III funds being used to address the academic impact of lost instructional time
$63,575

Plan Alignment (if applicable)	Action Title	Action Description	Planned ESSER III Funded Expenditures
n/a	Summer School	Provide summer school instruction to students achieving below grade level	$38,575
ELO	Small Group/One-One Instruction	Hire a new intervention paraprofessional to support increased small group and one-on-one instruction (funded with ELO and ESSER III funds over two years, continuing with LCAP funds if budget allows)	$25,000

Use of Any Remaining Funds

A description of the how the LEA will use any remaining ESSER III funds, as applicable.

Total ESSER III funds being used to implement additional actions
0

Plan Alignment (if applicable)	Action Title	Action Description	Planned ESSER III Funded Expenditures

Ensuring Interventions are Addressing Student Needs

The LEA is required to ensure its interventions will respond to the academic, social, emotional, and mental health needs of all students, and particularly those students most impacted by the COVID–19 pandemic. The following is the LEA's plan for ensuring that the actions and expenditures in the plan are addressing the identified academic, social, emotional, and mental health needs of its students, and particularly those students most impacted by the COVID–19 pandemic.

Action Title(s)	How Progress will be Monitored	Frequency of Progress Monitoring
COVID-19 Safety Supplies	Financial records reflecting the purchase of cleaning supplies, masks, outdoor learning support	Annually
Staff Expansion/Small Group/One-on-one instructional Support	"Let's Go Learn" (LGL) adaptive computer-based assessment results in ELA and Mathematics	Trianually
Social and Emotional Support	1. Student data recorded by the counselor; professional development and collaboration records for counselors. 2. A monthly student survey given through Kelvin, a computer-based student survey platform that assesses student well-being.	Daily, weekly, monthly, annually
Summer School	Attendance Rates and Records for Summer School	Daily

ESSER III Expenditure Plan Instructions

Introduction

School districts, county offices of education (COEs), or charter schools, collectively known as local educational agencies (LEAs), that receive Elementary and Secondary School Emergency Relief (ESSER) funds under the American Rescue Plan (ARP) Act, referred to as ESSER III funds, are required to develop a plan for how they will use ESSER III funds to, at a minimum, address students' academic, social, emotional, and mental health needs, as well as the opportunity gaps that existed before, and were exacerbated by, the COVID-19 pandemic.

The plan must be adopted by the local governing board or body of the LEA at a public meeting on or before October 29, 2021 and must be submitted for review and approval within five days of adoption. A school district must submit its ESSER III Expenditure Plan to its COE for review and approval; a COE must submit its plan to the California Department of Education for review and approval. A charter school must submit its plan to its chartering authority for review and to the COE of the county in which the charter school operates for review and approval.

In addition, consistent with the requirements of the ARP, Volume 86, *Federal Register*, page 21201, April 22, 2021, the ESSER III Expenditure Plan must be:

- Written in an understandable and uniform format;
- Written in a language that parents can understand, to the extent practicable;
  - If it is not practicable to provide written translations to a parent with limited English proficiency, the plan must be orally translated for parents
- Provided in an alternative format to a parent who is an individual with a disability as defined by the Americans with Disabilities Act, upon request; and
- Be made publicly available on the LEA's website.

For additional information regarding ESSER III funding please see the ARP Act Funding web page at https://www.cde.ca.gov/fg/cr/arpact.asp.

For technical assistance related to the completion of the ESSER III Expenditure Plan, please contact EDReliefFunds@cde.ca.gov.

Fiscal Requirements

- The LEA must use at least 20 percent (20%) of its ESSER III apportionment for expenditures related to addressing the academic impact of lost instructional time through the implementation of evidence-based interventions, such as summer learning or summer enrichment, extended day, comprehensive afterschool programs, or extended school year programs.
  - For purposes of this requirement, "evidence-based interventions" include practices or programs that have **evidence** to show that they are effective at producing results and improving outcomes when implemented. This kind of evidence has generally been produced through formal studies and research. There are four tiers, or levels, of evidence:

        - **Tier 1 – Strong Evidence**: the effectiveness of the practices or programs is supported by one or more well-designed and well-implemented randomized control experimental studies.
        - **Tier 2 – Moderate Evidence**: the effectiveness of the practices or programs is supported by one or more well-designed and well-implemented quasi-experimental studies.
        - **Tier 3 – Promising Evidence**: the effectiveness of the practices or programs is supported by one or more well-designed and well-implemented correlational studies (with statistical controls for selection bias).
        - **Tier 4 – Demonstrates a Rationale**: practices that have a well-defined logic model or theory of action, are supported by research, and have some effort underway by a State Educational Agency, LEA, or outside research organization to determine their effectiveness.
    - **For additional information please see the Evidence-Based Interventions Under the ESSA web page at** https://www.cde.ca.gov/re/es/evidence.asp**.**
- The LEA must use the remaining ESSER III funds consistent with section 2001(e)(2) of the ARP Act, including for:
    - Any activity authorized by the Elementary and Secondary Education Act (ESEA) of 1965;
    - Any activity authorized by the Individuals with Disabilities Education Act (IDEA);
    - Any activity authorized by the Adult Education and Family Literacy Act;
    - Any activity authorized by the Carl D. Perkins Career and Technical Education Act of 2006;
    - Coordination of preparedness and response efforts of LEAs with State, local, Tribal, and territorial public health departments, and other relevant agencies, to improve coordinated responses among such entities to prevent, prepare for, and respond to COVID-19;
    - Activities to address the unique needs of low-income students, students with disabilities, English learners, racial and ethnic minorities, homeless students, and foster youth, including how outreach and service delivery will meet the needs of each population;
    - Developing and implementing procedures and systems to improve the preparedness and response efforts of LEAs;
    - Training and professional development for staff of the LEA on sanitation and minimizing the spread of infectious diseases;
    - Purchasing supplies to sanitize and clean the facilities of an LEA, including buildings operated by such agency;
    - Planning for, coordinating, and implementing activities during long-term closures, including providing meals to eligible students, providing technology for online learning to all students, providing guidance for carrying out requirements under IDEA, and ensuring other educational services can continue to be provided consistent with all Federal, State, and local requirements;
    - Purchasing education technology (including hardware, software, and connectivity) for students who are served by the LEA that aids in regular and substantive educational interaction between students and their classroom instructors, including low-income students and children with disabilities, which may include assistive technology or adaptive equipment;
    - Providing mental health services and supports, including through the implementation of evidence-based full-service community schools;
    - Planning and implementing activities related to summer learning and supplemental after school programs, including providing classroom instruction or online learning during the summer months and addressing the needs of underserved students;

- Addressing learning loss among students, including underserved students, by:
  - Administering and using high-quality assessments that are valid and reliable, to accurately assess students' academic progress and assist educators in meeting students' academic needs, including through differentiated instruction,
  - Implementing evidence-based activities to meet the comprehensive needs of students,
  - Providing information and assistance to parents and families of how they can effectively support students, including in a distance learning environment, and
  - Tracking student attendance and improving student engagement in distance education;

  Note: A definition of "underserved students" is provided in the Community Engagement section of the instructions.
- School facility repairs and improvements to enable operation of schools to reduce risks of virus transmission and exposure to environmental health hazards, and to support student health needs;
- Inspection, testing, maintenance, repair, replacement, and upgrade projects to improve the indoor air quality in school facilities, including mechanical and nonmechanical heating, ventilation, and air conditioning systems, filtering, purification and other air cleaning, fans, control systems, and window and door replacement;
- Developing strategies and implementing public health protocols including, to the greatest extent practicable, policies in line with guidance from the Centers for Disease Control and Prevention (CDC) for the reopening and operation of school facilities to effectively maintain the health and safety of students, educators, and other staff;
- Other activities that are necessary to maintain the operation of and continuity of services in LEAs and continuing to employ existing staff of the LEA.

Other LEA Plans Referenced in this Plan

In developing the plan, the LEA has flexibility to include community input and/or actions included in other planning documents, such as the Local Control and Accountability Plan (LCAP) and/or the Expanded Learning Opportunities (ELO) Grant Plan, provided that the input and/or actions address the requirements of the ESSER III Expenditure Plan.

An LEA that chooses to utilize community input and/or actions from other planning documents must provide the name of the plan(s) referenced by the LEA and a description of where the plan(s) may be accessed by the public (such as a link to a web page or the street address of where the plan(s) are available) in the table. The LEA may add or delete rows from the table as necessary.

An LEA that chooses not to utilize community input and/or actions from other planning documents may provide a response of "Not Applicable" in the table.

Summary of Expenditures

The Summary of Expenditures table provides an overview of the ESSER III funding received by the LEA and how the LEA plans to use its ESSER III funds to support the strategies and interventions being implemented by the LEA.

Instructions

For the ‘Total ESSER III funds received by the LEA,’ provide the total amount of ESSER III funds received by the LEA.

In the Total Planned ESSER III Expenditures column of the table, provide the amount of ESSER III funds being used to implement the actions identified in the applicable plan sections.

For the ‘Total ESSER III funds included in this plan,’ provide the total amount of ESSER III funds being used to implement actions in the plan.

Community Engagement

Purpose and Requirements

An LEA’s decisions about how to use its ESSER III funds will directly impact the students, families, and the local community, and thus the LEA’s plan must be tailored to the specific needs faced by students and schools. These community members will have significant insight into what prevention and mitigation strategies should be pursued to keep students and staff safe, as well as how the various COVID–19 prevention and mitigation strategies impact teaching, learning, and day-to-day school experiences.

An LEA must engage in meaningful consultation with the following community members, as applicable to the LEA:

- Students;
- Families, including families that speak languages other than English;
- School and district administrators, including special education administrators;
- Teachers, principals, school leaders, other educators, school staff, and local bargaining units, as applicable.

“Meaningful consultation” with the community includes considering the perspectives and insights of each of the required community members in identifying the unique needs of the LEA, especially related to the effects of the COVID-19 pandemic. Comprehensive strategic planning will utilize these perspectives and insights to determine the most effective strategies and interventions to address these needs through the programs and services the LEA implements with its ESSER III funds.

Additionally, an LEA must engage in meaningful consultation with the following groups to the extent that they are present or served in the LEA:

- Tribes;
- Civil rights organizations, including disability rights organizations (e.g. the American Association of People with Disabilities, the American Civil Liberties Union, National Association for the Advancement of Colored People, etc.); and
- Individuals or advocates representing the interests of children with disabilities, English learners, homeless students, foster youth, migratory students, children who are incarcerated, and other underserved students.
  - For purposes of this requirement “underserved students” include:
    - Students who are low-income;

- Students who are English learners;
- Students of color;
- Students who are foster youth;
- Homeless students;
- Students with disabilities; and
- Migratory students.

LEAs are also encouraged to engage with community partners, expanded learning providers, and other community organizations in developing the plan.

Information and resources that support effective community engagement may be found under *Resources* on the following web page of the CDE's website: https://www.cde.ca.gov/re/lc.

Instructions

In responding to the following prompts, the LEA may reference or include input provided by community members during the development of existing plans, including the LCAP and/or the ELO Grant Plan, to the extent that the input is applicable to the requirements of the ESSER III Expenditure Plan. Descriptions provided should include sufficient detail yet be sufficiently succinct to promote a broad understanding among the LEA's local community.

A description of the efforts made by the LEA to meaningfully consult with its required community members and the opportunities provided by the LEA for public input in the development of the plan.

A sufficient response to this prompt will describe how the LEA sought to meaningfully consult with its required community members in the development of the plan, how the LEA promoted the opportunities for community engagement, and the opportunities that the LEA provided for input from the public at large into the development of the plan.

As noted above, a description of "meaningful consultation" with the community will include an explanation of how the LEA has considered the perspectives and insights of each of the required community members in identifying the unique needs of the LEA, especially related to the effects of the COVID-19 pandemic.

A description of the how the development of the plan was influenced by community input.

A sufficient response to this prompt will provide clear, specific information about how input from community members and the public at large was considered in the development of the LEA's plan for its use of ESSER III funds. This response must describe aspects of the ESSER III Expenditure Plan that were influenced by or developed in response to input from community members.

- For the purposes of this prompt, "aspects" may include:
  - Prevention and mitigation strategies to continuously and safely operate schools for in-person learning;

- Strategies to address the academic impact of lost instructional time through implementation of evidence-based interventions (e.g. summer learning or summer enrichment, extended day, comprehensive afterschool programs, or extended school year programs);
- Any other strategies or activities implemented with the LEA's ESSER III fund apportionment consistent with section 2001(e)(2) of the ARP Act; and
- Progress monitoring to ensure interventions address the academic, social, emotional, and mental health needs for all students, especially those students disproportionately impacted by COVID-19

For additional information and guidance, please see the U.S. Department of Education's Roadmap to Reopening Safely and Meeting All Students' Needs Document, available here: https://www2.ed.gov/documents/coronavirus/reopening-2.pdf.

Planned Actions and Expenditures

Purpose and Requirements

As noted in the Introduction, an LEA receiving ESSER III funds is required to develop a plan to use its ESSER III funds to, at a minimum, address students' academic, social, emotional, and mental health needs, as well as the opportunity gaps that existed before, and were exacerbated by, the COVID-19 pandemic.

Instructions

An LEA has the flexibility to include actions described in existing plans, including the LCAP and/or ELO Grant Plan, to the extent that the action(s) address the requirements of the ESSER III Expenditure Plan. When including action(s) from other plans, the LEA must describe how the action(s) included in the ESSER III Expenditure Plan supplement the work described in the plan being referenced. The LEA must specify the amount of ESSER III funds that it intends to use to implement the action(s); these ESSER III funds must be in addition to any funding for those action(s) already included in the plan(s) referenced by the LEA. Descriptions of actions provided should include sufficient detail yet be sufficiently succinct to promote a broad understanding among the LEA's local community.

Strategies for Continuous and Safe In-Person Learning

Provide the total amount of funds being used to implement actions related to Continuous and Safe In-Person Learning, then complete the table as follows:

- If the action(s) are included in another plan, identify the plan and provide the applicable goal and/or action number from the plan. If the action(s) are not included in another plan, write "N/A".
- Provide a short title for the action(s).
- Provide a description of the action(s) the LEA will implement using ESSER III funds for prevention and mitigation strategies that are, to the greatest extent practicable, in line with the most recent CDC guidance, in order to continuously and safely operate schools for in-person learning.

- Specify the amount of ESSER III funds the LEA plans to expend to implement the action(s); these ESSER III funds must be in addition to any funding for those action(s) already included in the plan(s) referenced by the LEA.

Addressing the Impact of Lost Instructional Time

As a reminder, the LEA must use not less than 20 percent of its ESSER III funds to address the academic impact of lost instructional time. Provide the total amount of funds being used to implement actions related to addressing the impact of lost instructional time, then complete the table as follows:

- If the action(s) are included in another plan, identify the plan and provide the applicable goal and/or action number from the plan. If the action(s) are not included in another plan, write "N/A".
- Provide a short title for the action(s).
- Provide a description of the action(s) the LEA will implement using ESSER III funds to address the academic impact of lost instructional time through the implementation of evidence-based interventions, such as summer learning or summer enrichment, extended day, comprehensive afterschool programs, or extended school year programs.
- Specify the amount of ESSER III funds the LEA plans to expend to implement the action(s); these ESSER III funds must be in addition to any funding for those action(s) already included in the plan(s) referenced by the LEA.

Use of Any Remaining Funds

After completing the Strategies for Continuous and Safe In-Person Learning and the Addressing the Impact of Lost Instructional Time portions of the plan, the LEA may use any remaining ESSER III funds to implement additional actions to address students' academic, social, emotional, and mental health needs, as well as to address opportunity gaps, consistent with the allowable uses identified above in the Fiscal Requirements section of the Instructions. LEAs choosing to use ESSER III funds in this manner must provide the total amount of funds being used to implement actions with any remaining ESSER III funds, then complete the table as follows:

- If the action(s) are included in another plan, identify the plan and provide the applicable goal and/or action number from the plan. If the action(s) are not included in another plan, write "N/A".
- Provide a short title for the action(s).
- Provide a description of any additional action(s) the LEA will implement to address students' academic, social, emotional, and mental health needs, as well as to address opportunity gaps, consistent with the allowable uses identified above in the Fiscal Requirements section of the Instructions. If an LEA has allocated its entire apportionment of ESSER III funds to strategies for continuous and safe in-person learning and/or to addressing the impact of lost instructional time, the LEA may indicate that it is not implementing additional actions.
- Specify the amount of ESSER III funds the LEA plans to expend to implement the action(s); these ESSER III funds must be in addition to any funding for those action(s) already included in the plan(s) referenced by the LEA. If the LEA it is not implementing additional actions the LEA must indicate "$0".

Ensuring Interventions are Addressing Student Needs

The LEA is required to ensure its interventions will respond to the academic, social, emotional, and mental health needs of all students, and particularly those students most impacted by the COVID–19 pandemic, including students from low-income families, students of color, English learners, children with disabilities, students experiencing homelessness, children in foster care, and migratory students.

The LEA may group actions together based on how the LEA plans to monitor the actions' progress. For example, if an LEA plans to monitor the progress of two actions in the same way and with the same frequency, the LEA may list both actions within the same row of the table. Each action included in the ESSER III Expenditure Plan must be addressed within the table, either individually or as part of a group of actions.

Complete the table as follows:

- Provide the action title(s) of the actions being measured.
- Provide a description of how the LEA will monitor progress of the action(s) to ensure that they are addressing the needs of students.
- Specify how frequently progress will be monitored (e.g. daily, weekly, monthly, every 6 weeks, etc.).

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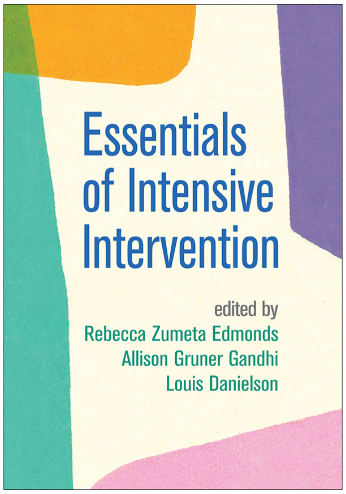

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Essentials of Intensive Intervention

Edited by **Rebecca Zumeta Edmonds**, **Allison Gruner Gandhi**, and **Louis Danielson**

"School psychologists are often a part of teams that address the lack of progress students are making academically and socially. This book gives school psychologists and other school staff background knowledge on the [data-based intervention] (DBI) process. It also provides detailed information and examples on how to implement it for different populations within the school system. Also, resources for each step of the DBI process are provided….I appreciate that the authors outlined the considerations for effective implementation."
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One to One Computing: A Summary of the Quantitative Results from the Berkshire Wireless Learning Initiative

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Special Edition:
Educational Outcomes and Research from 1:1 Computing Settings

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EDUCATIONAL OUTCOMES & RESEARCH FROM 1 TO 1 COMPUTING SETTINGS

This special issue of the Journal of Technology, Learning, and Assessment focuses on the educational impacts and outcomes of 1:1 computing initiatives and technology-rich K–12 environments. Despite growing interest in and around 1:1 computing, little published research has focused on teaching and learning in these intensive computing environments. This special issue provides a forum for researchers to present empirical evidence on the effectiveness of 1:1 computing models for improving teacher and student outcomes, and to discuss the methodological challenges and solutions for assessing the effectiveness of these emerging technology-rich educational settings.

Complete listing of papers published within the JTLA 1:1 Special Edition

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Shapley, K.S., Sheehan, D., Maloney, C., & Caranikas-Walker, F. (2010). Evaluating the Implementation Fidelity of Technology Immersion and its Relationship with Student Achievement. *Journal of Technology, Learning, and Assessment, 9*(4).

Suhr, K.A., Hernandez, D.A., Grimes, D., & Warschauer, M. (2010). Laptops and Fourth-Grade Literacy: Assisting the Jump over the Fourth-Grade Slump. *Journal of Technology, Learning, and Assessment, 9*(5).

Weston, M.E. & Bain, A. (2010). The End of Techno-Critique: The Naked Truth about 1:1 Laptop Initiatives and Educational Change. *Journal of Technology, Learning, and Assessment, 9*(6).

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Abstract:

This paper examines the educational impacts of the Berkshire Wireless Learning Initiative (BWLI), a pilot program that provided 1:1 technology access to all students and teachers across five public and private middle schools in western Massachusetts. Using a pre/post comparative study design, the current study explores a wide range of program impacts over the three years of the project's implementation. Specifically, the current document provides an overview of the project background, implementation, research design and methodology, and a summary of the quantitative results. The study details how teaching and learning practices changed when students and teachers were provided with laptops, wireless learning environments, and additional technology resources. The results found that both the implementation and outcomes of the program were varied across the five 1:1 settings and over the three years of the student laptop implementation. Despite these differences, there was evidence that the types of educational access and opportunities afforded by 1:1 computing through the pilot program led to measurable changes in teacher practices, student achievement, student engagement, and students' research skills.

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One to One Computing: A Summary of the Quantitative Results from the Berkshire Wireless Learning Initiative

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> All of us, professionals as well as laymen, must consciously break the habits we bring to thinking about the computer. Computation is in its infancy. It is hard to think about computers of the future without projecting onto them the properties and the limitations of those we think we know today. And nowhere is this more true than in imagining how computers can enter the world of education.
>
> —Seymour Papert, *Mindstorms* (2nd Ed.)

Introduction

Few modern educational initiatives have been as widespread, dramatic, and costly as the integration of computer technologies into American classrooms. Believing that increased use of computers will lead to improved teaching and learning, greater efficiency, and the development of important skills in students, educational leaders have made multi-billion dollar investments in educational technologies such that the national ratio of students to computers has dropped from 125:1 in 1983 to 4:1 in 2002 (where it has largely remained) (Russell, Bebell, & Higgins, 2004). While access to computers has increased, teachers and students in traditional school environments generally report using computers in schools for only a small amount of time each day (Bebell, Russell, & O'Dwyer, 2004; Russell, Bebell, O'Dwyer, & O'Connor, 2003; Ravitz, Wong, & Becker, 1999). Despite the many ways in which computers can be distributed within schools (e.g., in labs, libraries, or on shared carts), many observers theorize that the disjuncture between the dramatic increase in the presence of computers in schools and the relatively stagnant amount of use results in part because student-to-computer ratios have not yet reached a stage at which the technology is ubiquitous (Bull, Bull, Garofolo, & Harris, 2002; Papert, 1996; Rockman, 1998, Cuban, 2006).

Both proponents and opponents of educational technology agree that the full effects of computers in school cannot be fully realized until the technology is no longer a shared resource (Oppenheimer, 2003; Papert, 1992, 1996). In the past decade, a new educational reality has emerged where technology resources are no longer shared as thousands of teachers and students have been provided with their own laptop computers in school. In 2003–2004, it was estimated that 4% of the nation's school districts were implementing some form of 1:1 computing. In 2006, it was estimated that close to 25% of school districts are implementing some form of a 1:1 laptop program (eSchool News, 2006). 1:1 programs currently exist across the nation in a wide variety of settings including large-scale 1:1 initiatives in South Dakota, Pennsylvania, New Hampshire, Texas, Georgia, Louisiana, California, Virginia, Florida, Kansas, Maine, Massachusetts, and Michigan. In addition, increased international attention has been focused on the adoption of 1:1 computing through programs such as the "One Laptop Per Child" Initiative and Intel's "World Ahead Program", which seek to provide bulk quantities of inexpensive laptop computers for educational purposes to children in third world countries (www.laptop.org).

Despite growing interest in and excitement about 1:1 computing, there has generally been a lack of large-scale research and evaluation studies focusing on teaching and learning in these intensive computing environments (Penuel, 2006). However, early studies suggest several positive outcomes emerging from 1:1 laptop initiatives including: increased student engagement (Cromwell, 1999; Rockman, 1998; MEPRI, 2003; Bebell, 2005; Penuel, 2006), decreased disciplinary problems (Baldwin, 1999; MEPRI, 2003), increased use of computers for writing, analysis and research (Cromwell, 1999; Baldwin, 1999; Guignon, 1998; Russell, Bebell, & Higgins, 2004; Penuel, 2006), and a movement towards student-centered classrooms (Rockman, 1998). Baldwin (1999) also documented effects on student behaviors at home such that students reported spending less time watching television and more time on homework. Similarly, Russell, Bebell and Higgins (2004) reported that students' academic use of computers at home occurred more frequently when students were provided with their own laptops.

In the past few years, a number of studies have begun to focus more specifically on the relationship between student achievement and participation in 1:1 programs, but have not always included measures of specific technology uses. For example, Gulek and Demirtas (2005) examined test scores between students participating and not participating in a voluntary 1:1 laptop program at a middle school in Pleasanton, California. A significant difference in both math and ELA test scores was found for students participating in the program one year or more, even after statistically controlling for prior achievement levels. An urban middle school study (Dunleavy & Heinecke, 2007) randomly selected students from a school population to participate in 1:1 laptop classrooms or non-1:1 laptop classrooms. The researchers discovered a significant increase in overall science test scores as well as a significant gender interaction whereby boys had a much greater increase in scores in the 1:1 laptop program than girls. More recently, a 1:1 research symposium at the 2008 meeting of the American Educational Research Association included evidence from Maine's statewide 1:1 program (Silvernail, 2008) and Texas' Technology Immersion Program (Shapley, 2008) that found students in 1:1 middle school classrooms had statistically significant improvements in English Language Arts achievement, but not in Mathematics.

Given these measures of success, 1:1 computing has captured the imagination of many educational and political leaders looking to reform educational practices and improve underperforming schools. In addition, a number of political leaders have suggested that providing students access to powerful computing technologies may significantly contribute to long-term economic prosperity. Within school settings, the promise of 1:1 computing has also taken root; nearly 50% of school district chief technology officers reported in a recent national survey that they were likely to purchase a computing device for each student in their district by 2011 (Hayes, 2006).

The Berkshire Wireless Learning Initiative

The Berkshire Wireless Learning Initiative (BWLI) was a three-year pilot program across five western Massachusetts middle schools where every student and teacher was provided a laptop computer beginning in 2005. In addition, all classrooms were equipped with wireless Internet networks and selected classrooms with DLP/LCD projectors, as well as technical and curricular professional development and support to help teachers integrate the new technology into their curriculum. The $5.3 million dollar program[1] was funded through a combination of district-level school funds, state funds, as well as local business contributions. Launched midway during the 2005–2006 school year, the initiative (as well as the accompanying research) continued through the 2007–2008 academic year.

The overall aim of the pilot program was to determine the efficacy of a one-to-one laptop initiative in transforming teaching and learning in a traditional middle school setting. Specifically, the targeted outcomes of the BWLI included: enhancing student achievement, improving student engagement, improving classroom management, enhancing students' capabilities to conduct independent research and collaborate with their peers, as well as creating fundamental changes in teaching strategies and curriculum delivery. The research efforts employed a pre/post with comparison group design to examine the effects of 1:1 technology on students and teachers across the five participating schools. In addition to following the cohorts of students over three years of the 1:1 technology implementation, the researchers also collected comparison data from two neighboring public middle schools with similar demographics. A summary of the participating schools in the BWLI research study are displayed in Table 1.

Table 1: Summary of Schools Participating in the BWLI Research

School Name	District	Classification	Grades	School Type
Conte	North Adams Public	BWLI	6, 7, 8	Public
Herberg	Pittsfield Public	BWLI	6, 7, 8	Public
Reid	Pittsfield Public	BWLI	6, 7, 8	Public
St. Mark	Catholic Schools of Pittsfield	BWLI	Pre-K to 7	Parochial
St. Joseph	Catholic Schools of Pittsfield	BWLI	8, 9, 10, 11, 12	Parochial
North	Westfield Public	Comparison	6, 7, 8	Public
South	Westfield Public	Comparison	6, 7, 8	Public

In early January 2006, each of the seventh grade students across the five participating schools (n = 633) received Apple iBook G4 laptops for use during the remaining first year of the BWLI implementation. In the first months of the second and third year of the laptop implementation all sixth, seventh, and eighth grade students across each participating school were provided iBook G4 laptops for the majority of the 2006–2007 and 2007–2008 school year (n = 1700+/–).

Study Methodology and Data Sources

Program Objectives and Study Design Overview

To directly meet the needs of the project stakeholders, the current study aimed to document how successfully the BWLI program achieved the following targeted outcomes:

1. Enhanced student achievement;
2. Improved student engagement;
3. Fundamental changes in teaching strategies, curriculum delivery, and classroom management; and

4. Enhanced capabilities among students to conduct independent research, and collaborate with peers.

Although the current paper focuses largely on the quantitative results, the three year study employed teacher surveys, selected teacher interviews, student surveys, student drawings, analysis of existing school records and test scores, as well as classroom observations to document and track the impacts of 1:1 computing on teaching and learning practices across the five experimental settings. Student achievement was examined using student level MCAS (Massachusetts Comprehensive Assessment System) test data in the three participating public schools and two comparison schools in a non-equivalent comparison group design study. Lastly, an additional student writing assessment was undertaken in Spring 2008 whereby 1:1 seventh grade students were randomly assigned to complete an extended writing exercise using either their laptop or using traditional paper and pencil. Table 2 provides brief descriptions for each data collection procedure linked to the original targeted outcomes.

Table 2: Data Collection Procedures and Targeted Project Outcomes

Procedure	Description	Outcome(s)
Student Survey	Web-based student surveys were given to all participating BWLI and comparison group students both before (Pre) and during the laptop implementation (Post).	1, 2, 3, 4
Teacher Survey	Web-based teacher surveys were given to all participating BWLI and comparison group teachers before their students experienced 1:1 computing (Pre) and again near the end of each 1:1 school year (Post).	1, 2, 3, 4
Student Drawing	A student drawing exercise asked BWLI students to reflect on "writing in school" through an open ended drawing exercise before they experienced 1:1 computing (Pre) and again near the end of each 1:1 school year (Post).	2, 3, 4
Classroom Observation	Trained researchers and college students conducted pre-arranged visits to observe and record technology practices in 1:1 classrooms during the second year of program implementation.	2, 3, 4
Student Achievement Study	Research team analyzed 2006-2008 item-level MCAS results for each participating BWLI and comparison group student to determine the impacts of various technology practices (as measured via surveys) on standardized test performance.	1
Computer Writing Assessment	1:1 BWLI students were randomly selected in Spring 2008 (Year 3) to participate in an extended computer-based writing assessment to determine the impacts of technology practices on writing length and quality.	1
Teacher Interviews	At various intervals across the deployment of 1:1 student laptops, samples of BWLI teachers participated in short informal interviews regarding their progress, attitudes, and results related to the program.	2, 3, 4
Principal Interviews	At various intervals across the deployment of 1:1 student laptops, BWLI principals participated in short informal and formal interviews regarding their progress, attitudes, and outcomes related the program.	1, 2, 3, 4

It is important to note that each of the participating 1:1 schools varied the deployment and management of the laptop program to best suit the needs of their own distinct educational community. Each school subscribed to its own nuanced resource allocation, training and professional development offerings, policies, and technical and curricular support. Even though the pilot program raised the overall level of technology so that every student and teacher had a laptop computer in school, some differences remained in the deployment and management of the program across the five settings. These differences are further explored in the results and discussion sections of this paper.

Student and Teacher Survey Response Rates

Student Survey

As more fully described in the BWLI Evaluation Plan and the 2009 evaluation report (Bebell & Russell, 2006; Bebell & Kay, 2009), all participating pilot students were required to complete a web-based survey focused on the frequency of varied technology uses both in and out of the classroom and across the curriculum in addition to demographic items and a brief attitudes and beliefs inventory.

Given that the first year of the program focused only on the seventh grade, 574 grade seventh students across the BWLI schools completed pre-1:1 laptop surveys in December 2005/January 2006 (90.4% of the 635 seventh grade students). After approximately five months of 1:1 computing, 524 of these seventh grade students completed a post-laptop survey in early June 2006 (or 82.5%). Upon the completion of the second year of the program (June 2007) when students across all grade levels (6–8) had access to laptops, the Year 2 online survey was collected from 1,839 of the potential 1,898 students resulting in a 96.8% response rate. In addition, students across the two comparison schools were also solicited to participate in the student survey. The June 2008 student survey response rates are presented below for each of the pilot and comparison schools in Table 3 (next page).

Table 3: Year 3 (2007–2008) Student Survey Response Rate

School Name	Student Population	Survey Responses	Response Rate
South Middle School	697	556	79.7%
North Middle School	790	553	70.0%
Total Comparison Schools	**1487**	**1109**	**74.6%**
Conte Middle School	318	318	100%
Herberg Middle School	699	691	98.9%
Reid Middle School	644	643	99.8%
St. Mark	84	84	100%
St. Joseph	41	26	63.4%
Total Pilot (1:1) Schools	**1786**	**1762**	**98.7%**

For the final student survey, a total of 1,109 students completed the Year 3 survey from the two comparison schools yielding a combined response rate of 74.6% while a response rate of 98.7% was achieved across the BWLI schools with 1762 out of 1786 eligible students completing the survey.

Teacher Survey

The online teacher survey focused on capturing the variety and extent of teachers' technology use, teachers' attitude toward technology, teaching, and learning, as well as teachers' beliefs on the effects of the pilot program. The teacher survey is one of the main foci of the current report. As more fully documented in the full BWLI evaluation report (Bebell & Kay, 2009), every teacher participating in the 1:1 program was surveyed prior to and during the three years of the program. In the current report, results from the final June 2008 teacher survey are compared to past survey administrations. Specifically, results from the first (January 2006) teacher survey again reflect a time when teachers had recently received their own laptops but students had not been issued computers. The May 2006 teacher survey administration asked teachers to focus on their first year experiences in the 1:1 program with seventh grade students having access to computers for the last five months of the year but still finding all the 6th and 8th grade students without computers. Teachers from comparison and pilot schools were surveyed again in June 2007, with 160 of the 168 total 1:1 teacher population responding (95% response rate). Given that the June 2008 data is detailed in the results section of this paper, a closer examination of the June 2008 final teacher survey response rates are presented below in Table 4 (next page).

Table 4: **Year 3 (2007–2008) Teacher Survey Response Rate**

School Name	Teacher Population	Survey Responses	Response Rate
South Middle School	80	49	61.3%
North Middle School	73	39	53.4%
Total Comparison Schools	**153**	**88**	**57.6%**
Conte Middle School	42	42	100%
Herberg Middle School	59	59	100%
Reid Middle School	58	58	100%
St. Mark	5	4	80%
St. Joseph	3	0	0%
Total BWLI Schools	**167**	**163**	**97.6%**

For the final teacher survey, a total of 88 teachers completed the survey across the two comparison schools yielding a combined response rate of 57.6% while the response rate was substantially higher across the pilot schools with 163 out of 167 teachers completing the survey (97.6% response rate). Of the 163 teachers across the four pilot schools who completed the BWLI teacher survey, 109 were classified as teaching one of the focused primary subject areas (English/Language Arts, Math, Science, Social Studies). In addition to the 109 primary subject classroom teachers the survey was also completed by an addition 54 teachers and educators who taught subjects including: physical education, special education, reading intervention, foreign languages, and health. To simplify the interpretation of the results, the current report only presents survey results from the 109 primary subject teachers. Interestingly, the differences between the survey responses of the 109 primary subject classroom teachers and the other subject area specialists concerning the impacts of the BWLI program were largely negligible.

Exploring the Impact of 1:1 Computing on Student Achievement

School and Student Level MCAS Analyses

Given that the first targeted outcome of the state's pilot 1:1 program was to "enhance student achievement" a central component of the current investigation was addressing how 1:1 participation and technology use impacted student test scores. Specifically, the current investigation addressed:

- trends in schools' overall MCAS performance over time compared to the comparison schools and state trends during this same period, and
- which, if any, of students' technology uses in school or at home are related to student-level performance on various MCAS measures (while statistically controlling for students' pre-BWLI academic performance using prior MCAS performance)

School-level MCAS results and performance indicators from 1998 to 2008 were accessed from the Massachusetts Department of Education while student level data was provided to the research team directly from the participating schools for 2005-2008. To facilitate our analyses of how different types of student use impacted student test performance, grade 7 and 8 student survey results across all BWLI and comparison students were merged with the item-level MCAS data. Because only public school students participated in the mandatory MCAS state assessment, only results from the three BWLI public schools and the two comparison schools were available for use. Thus, for each grade level, a new data set was created that included student level MCAS and demographic information as well as the BWLI student survey data on technology use and practices. So, for each seventh and eighth grade student who completed the MCAS and the BWLI survey, the relationship between various technology uses and various outcome/student achievement measures could be examined. Since nearly all students in the pilot public schools completed both the MCAS and the BWLI student survey in Spring 2008, we are able to perform our investigation with a highly representative sample of 1:1 student participants. Table 5, next page, summarizes the MCAS subject tests schedule used by the state across the years of the 1:1 pilot program.

Table 5: Summary of Student Level MCAS Administration Results Across Subjects and BWLI Student Laptop Deployment Schedule

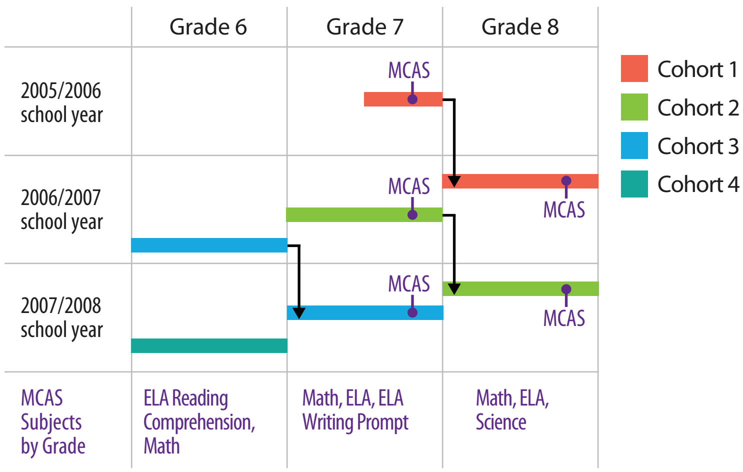


Table 5 provides a summary of outcome measures that are available for each student cohort (grade 7 and grade 8) in our analyses of achievement. In the final year of the BWLI program, grade 8 students completed the Spring 2008 MCAS testing in English language arts (ELA), math, and science. These assessments were completed after nearly two full school years participating in the 1:1 student laptop program (throughout grade 7 and 8). Using linear regression, our student-level analyses of achievement techniques used Spring 2008 student MCAS scores as the dependent or outcome variable while students' individual MCAS scores from their 6th grade (pre-BWLI laptops) serve as an independent variable to account (or control) for students' prior level achievement. More information about the MCAS, the Massachusetts high-stakes assessment can be found at the Massachusetts Department of Education website: www.doe.mass.edu.

Computer Writing Assessment

Like the rest of the MCAS, the grade 7 ELA open-ended writing assessment is completed using paper and pencil, which research suggests may serve to underestimate the writing ability of students grown accustomed to composing and editing text on a computer (Russell & Plati, 2001; Russell, 1999; Russell & Haney, 1997). In response to this literature, an investigation of students' computer writing ability was also incorporated into the current study. Specifically, in Spring 2008, seventh grade students across all participating pilot schools were randomly assigned at the classroom or student level (depending on school) to complete a mock-MCAS open response assessment using either their BWLI laptops or the traditional paper/pencil required by the state.

A publicly-released writing prompt from a prior (2006) MCAS ELA assessment was used for the BWLI computer writing study. The chief difference between the actual MCAS administration of the ELA writing assessment and the BWLI computer writing study was that in our study students were randomly assigned to complete their essay using either their BWLI laptop or using paper and pencil. Since nearly all participants in our computer writing study (n = 451) would be taking the actual paper-based 7^{th} grade writing assessment later in the school year, a higher proportion of students (approximately two-thirds) were randomly assigned to the laptop setting.

Testing materials and directions were adapted for both the paper and computer testing classrooms, however the directions for the laptop students specified that all spell-checking, grammar-checking, and other automated features of Microsoft Word (students' most commonly used writing program) be turned off and/or removed to ensure that the only substantive difference between the computer and paper environments would be the mode of test administration. All other testing circumstances (time, resources, directions, scoring criteria, etc.) were held exactly the same to ensure a realistic and meaningful testing experience as well as to ensure valid results. Copies of all directions and materials used in the BWLI computer writing study are available at www.bc.edu/bwli.

To eliminate any scorer bias, a team of six trained education undergraduate students were recruited, trained, and employed to electronically input each of 141 paper essays (including all student mistakes, typos, etc.) into Microsoft Word. Once all the paper essays were successfully entered into an electronic format, a second team of eight undergraduate students completed formal training and reliability testing on the state's coding rubric to score the seventh grade essays. After this training, each member of the scoring team was provided a random sample of student essays to score whereby each essay was scored by two raters on two dimensions: Topic Development and Standard English Conventions.

Qualitative Inquiries: Student Drawings, Classroom Observations, Teacher Interviews, and School Leadership/Principal Interviews

Throughout the three-year implementation of the 1:1 program, members of the research and evaluation team made regular visits to each participating school to conduct classroom observations, informally interview teachers, and both formally and informally interview school principals as well as other building level and district level leadership. In addition, students across the 1:1 settings participated in a student drawing exercise whereby they depicted themselves "writing in school" both before and after implementation of the laptop program. In total, over 3500 student drawings were analyzed using an emergent analytic coding process established through prior student drawing and 1:1 research studies (Bebell, 2001; Bessette, 2008).

Although each of these qualitative inquires provided rich data sources and served multiple functions within the research study, the limited space herein does not allow a full discussion of these modes of inquiry and many of the specific findings they contributed. A larger discussion of these inquiries and specific study results can be found in the BWLI Final Report available at www.bc.edu/bwli (Bebell & Kay, 2009).

Results

There are limitless ways to summarize the variety of results and outcomes from such a complicated initiative. One of the most universal findings in the current investigation was that both the implementation and outcomes of the program were varied across the five 1:1 settings and over the three years of the student laptop implementation. The current results focus on those findings that were fairly universal across the five pilot settings while subsequent reports will focus on the more specific program differences between the schools.

Within months of the initial student implementation, teacher and student use of technology increased dramatically across the curriculum in nearly all of the participating classrooms. On average, teachers reported widespread adoption of new and novel approaches across their traditional curriculum, which were then subsequently reported by teachers and administration to increase student motivation and engagement, and to a somewhat lesser extent, academic performance. The majority of teachers adopted a wide variety of professional uses for technology including electronic record keeping, communication with other staff and parents via email, creation and management of web pages (often with posted homework, lesson plans, educational resources, etc.) as well as access to a nearly infinite collection of curricular and pedagogical resources via the Internet. It was observed that teachers, by default, served as gatekeepers to students' technology use throughout the school day while the three participating public schools struggled with maintaining effective student laptop take-home policies and practices. Although there often remained substantial variation in the frequency and ways different teachers chose to use the technology with their students, the majority of students and teachers altered their approach and practices since the introduction of laptops to the classroom.

In this section of the paper, we explore common trends across the various research results that directly address the original targeted project outcomes. Each of the four targeted outcomes (fundamental shifts in teaching practices, improved student engagement, enhanced student research and collaboration, and enhanced student achievement) are individually presented below with examples from supporting data sources. Again, a more thorough examination of all study results, including variations across the five 1:1 settings, can be found in the BWLI Final Report available at www.bc.edu/bwli (Bebell & Kay, 2009).

Fundamental Changes in Teaching Practices

One of the central project outcomes of the study was the documentation of fundamental changes in teaching, particularly teaching strategies, curriculum delivery, and classroom management. Without question, the 1:1 program had major impacts across many aspects of teaching for the majority of teacher participants. The chief results supporting this finding include the teacher survey, student survey, principal interviews, classroom observations, and teacher interviews. The first year of teacher and student survey results speak volumes about the speed at which teachers adopted and implemented technology across their professional lives. In short, teachers quickly adopted and incorporated technology into a wide variety of new practices beyond use with their students in the classroom (which had itself increased nearly four times within the first six months of the student deployment). By the third and final year of the 1:1 implementation, student and teacher practices incorporated substantial technology resources and tools in four of the five 1:1 pilot settings. For example, Figure 1 (next page) displays the average number of school days students reported using technology by primary subject area (2007–2008 school year).

Figure 1: Average Number of School Days Students Reported Using Technology by Primary Subject Area (2007–2008 School Year)

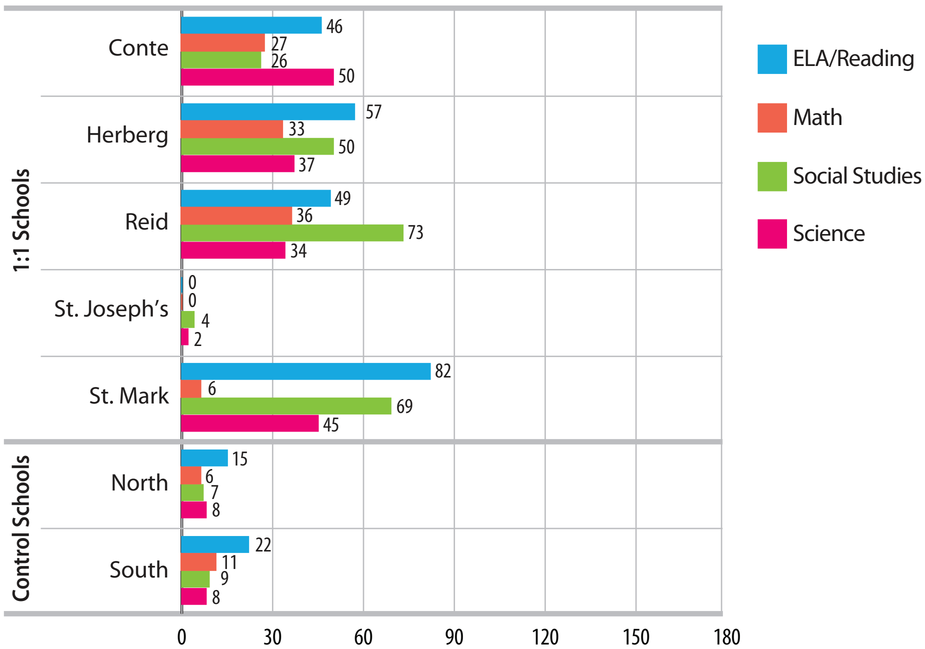


Figure 1 displays the average number of days students reported using computers across four primary subject areas during the potential 180 school days of the 2007–2008 school year. In the above figure, students' frequency of computer use is represented by four horizontal bars corresponding to the four surveyed subject areas. A number of interesting and noteworthy features are prominent in Figure 1. First, there is substantial variability in the frequency of use across subject areas within most of the pilot schools. For example, students across all grade levels at St. Mark reported using their computers over 80 times in ELA and nearly 70 times in Social Studies classes during the 2007–2008 school year while only 6 times in their Math classes. Looking across the schools for subject area trends, we find that in two of the five pilot schools, students used computers in Social Studies class more than other subjects, while students at Conte reported using computers the least in Social Studies. In other words, no single subject area received universally high use at more than two BWLI schools, suggesting that factors within each school play a large role in the adoption and student use of technology. Despite this within school variation, student use of technology in Math and Science classes were generally reported to be less frequent than in ELA and Social Studies classes when examined collectively across the pilot schools.

Looking cumulatively across the pilot school averages during the 2007–2008 school year we see that St. Joseph[2] students reported the least frequent use (6 instances of computer use across these primary subject areas during the 2007–2008 school year). Students at St. Mark's School reported the most frequent cumulative use with the average student reporting that they had used a computer across these four classes on 202 occasions during the school year. Close behind, the average Reid students reported 192 cumulative uses of a computer in these subjects across this same period while Herberg and Conte students reported 177 and 149 respective instances of computer use. What this means is that, on average, pilot students were typically using their laptop computers on a daily or slightly greater-than-daily basis in at least one of their primary subjects classes during the 2007–2008 school year, the second full year of the school wide 1:1 laptop implementation.

In the final teacher survey, nearly all of teachers (83%) reported that their own computer skills had improved since the beginning of the BWLI program. Teacher use of technology also increased dramatically as the program was implemented and for a wide variety of ways to support their work. For example, Table 6 (next page) illustrates pilot teachers' use of technology over time from the original January 2006 survey administration (pre-1:1 student access) to the final June 2008 survey.

Table 6: 1:1 Pilot Teachers' Use of Technology Over Time (Average Number Of School Days Per Year)

	Jan. 2006	May 2006	May 2007	June 2008
Use a computer to deliver instruction to your class	22.7	58.8	59.2	57.3
Prepare or maintain IEPs using a computer	17.0	9.0	18.4	15.8
Adapt an activity to students' individual needs using computers	13.2	32.2	28.2	31.2
Make handouts for students using a computer	51.6	50.8	60.7	69.6
Create a test, quiz, or assignment using a computer	49.0	46.8	56.0	60.3
Perform research and lesson planning using the Internet	56.9	73.9	80.6	85.6
Create WebQuests or build the Internet into a lesson	8.8	20.3	21.9	19.9
Use a computer to present information to your class	23.9	56.7	47.4	47.4
Use a computer to help students better understand a concept	23.6	50.2	45.2	46.3
Use a computer to model relationships and/or functions	13.0	29.4	19.3	20.8
Create and/or maintain web pages	26.5	na	78.6	57.0
Assess students using a computer (including a test, quiz, or practice test)	24.1	na	43.6	40.5
Use a computer to communicate with teachers, parents, or administrators	89.6	105.4	111.2	120.9

In addition to showing how frequently teachers used technology at various times during the pilot implementation, Table 6 also illustrates the wide variety of technology adoption and use by teachers. Some of the most frequent "behind the scenes" uses of technology for teachers included such diverse professional tasks as researching and acquiring curricular materials, using email as a school-wide communication system as well as with parents and students, scheduling, record keeping and grades, managing educational web sites for their students, and creating tests, quizzes or assignments. Clearly, teachers' non-instructional professional practices were impacted by the 1:1 initiative—representing a marked shift in many aspects of teaching. The impact of the new 1:1 technology applied during actual instructional time was somewhat less universally across all pilot classrooms, however the impact was still quite notable considering the major investments required by teachers to "transform" and "fundamentally change" their existing classroom practices.

The majority of teachers reported that they experienced marked shifts in their teaching. In the final survey administration, over 80% of pilot teachers reported that the delivery of curriculum within their classes had changed since their school began the 1:1 pilot program. In addition, slightly less than 60% of responding teachers believed that their school climate had changed as a result of the program and over 50% of teachers further believed that their role as a teacher within their own classroom had changed. In assessing the impact of these changes in their own teaching, teachers were largely positive with 62% of pilot teachers reporting that their teaching had "improved as a result of the 1:1 program" while less than 10% disagreed. In addition to the teacher's own reflection in the surveys, there were also numerous examples in the classroom observations, teacher interviews, and principal interviews of shifting teacher practices as a result of the 1:1 program.

Despite the majority of teachers reporting that 1:1 computing had led to changes in their teaching, almost everyone involved also expressed the sentiment that "even after a couple of years we still feel like were just getting accustomed to teaching in a 1:1 setting" echoing the sentiment that the impacts of the initiative could take many years to be fully realized. Finally, there remained a very small number of teachers who were only negligibly impacted by the pilot program and 1:1 computing. This small minority of staff generally felt satisfied with their pre-1:1 practices and teaching or were simply less confident experimenting with technology. However, the 1:1 pilot program substantially impacted many aspects of teachers' professional lives in the vast majority of participating classrooms, and often with positive results.

Improved Student Engagement

There is strong evidence that student engagement increased dramatically in response to the enhanced educational access and opportunities afforded by 1:1 computing through the pilot program. The chief results supporting this finding include the teacher survey, student survey, principal interviews, classroom observations, and teacher interviews.

In their final survey (June 2008) teachers overwhelmingly reported improvements in student engagement and motivation (see Figure 3). Specifically, eighty-three percent of teachers felt that engagement had improved for their traditional students, compared to 84% for at-risk/low achieving students, and 71% for high achieving students. Similar to the results on student engagement, teachers overwhelmingly found that the 1:1 pilot program enhanced their students' motivation. Seventy-six percent of 1:1 teachers reported that student motivation improved for their low achieving students compared to 73% for traditional students and 59%

for high achieving students. Conversely, a very small minority of teachers (less than 2%) believed that the 1:1 laptops had led to declined class participation and motivation for their students.

Similarly, the principals were as positive as the teachers in their belief that student participation in the program has led to dramatically improved student engagement in the classroom. Nearly all of the building leadership reported throughout the three-year implementation period that the majority of students responded very favorably to the laptop initiative and that students' engagement, attentiveness, and motivation was improved when they were using laptops in class.

Across the classroom observations, student engagement and motivation was directly observed in each of the 1:1 pilot settings throughout the deployment period. These observations across the five participating schools, serve to triangulate the survey and interview results showing that the majority of students were more engaged and motivated when provided the opportunity to use technology in their classes. In classroom observations, students would often walk into their class and greet the teacher by asking if they would be "using their laptops today." When a teacher would respond positively, students would often cheer and visibly express their pleasure. Once class was underway, the majority of students did appear to be more on task and engaged in their schoolwork when they were using their laptops. In fact, students typically appeared to be so much more engaged and generally on task when using laptops in class, that it became a frequent practice to encourage policy makers and educational observers to actually visit and observe 1:1 classes as evidence of the programs success, such as when Senator John Kerry visited the Conte Middle School's 1:1 classrooms in October 2007.

Both the classroom observations and teacher interviews also showed that student engagement could also be enhanced when the *teacher* used technology in class, such as a "cool" technology-enabled presentation to present curriculum.

Enhanced Student Research Skills and Collaboration

There is also evidence that student research skills and collaboration were enhanced by the improved educational access and opportunities afforded by the 1:1 pilot program. The chief results supporting this finding include the teacher and student survey data, teacher interviews, principal interviews, and classroom observations. Overall, the vast majority (about 95%) of 1:1 pilot program students reported having at least one computer accessible at home which was most typically connected to a high-speed Internet connection and used for over 60 minutes per day, on average. Thus, we can conclude that the vast majority of students entered the 1:1 laptop initiative with considerable computing and Internet experience.

Based on the early survey results, pilot students and teachers very quickly adopted the Internet as a research tool and resource. One of the most consistent results across the study findings has been the great frequency with which students reported using the Internet to access information in school. Both the frequency and widespread nature of this use suggests that students had increased their research opportunities and capabilities through the 1:1 initiative.

Figure 2: Frequency of 1:1 and Comparison Students' Various Computer Uses During The 2007–2008 School Year (Average Number of School Days per Year)

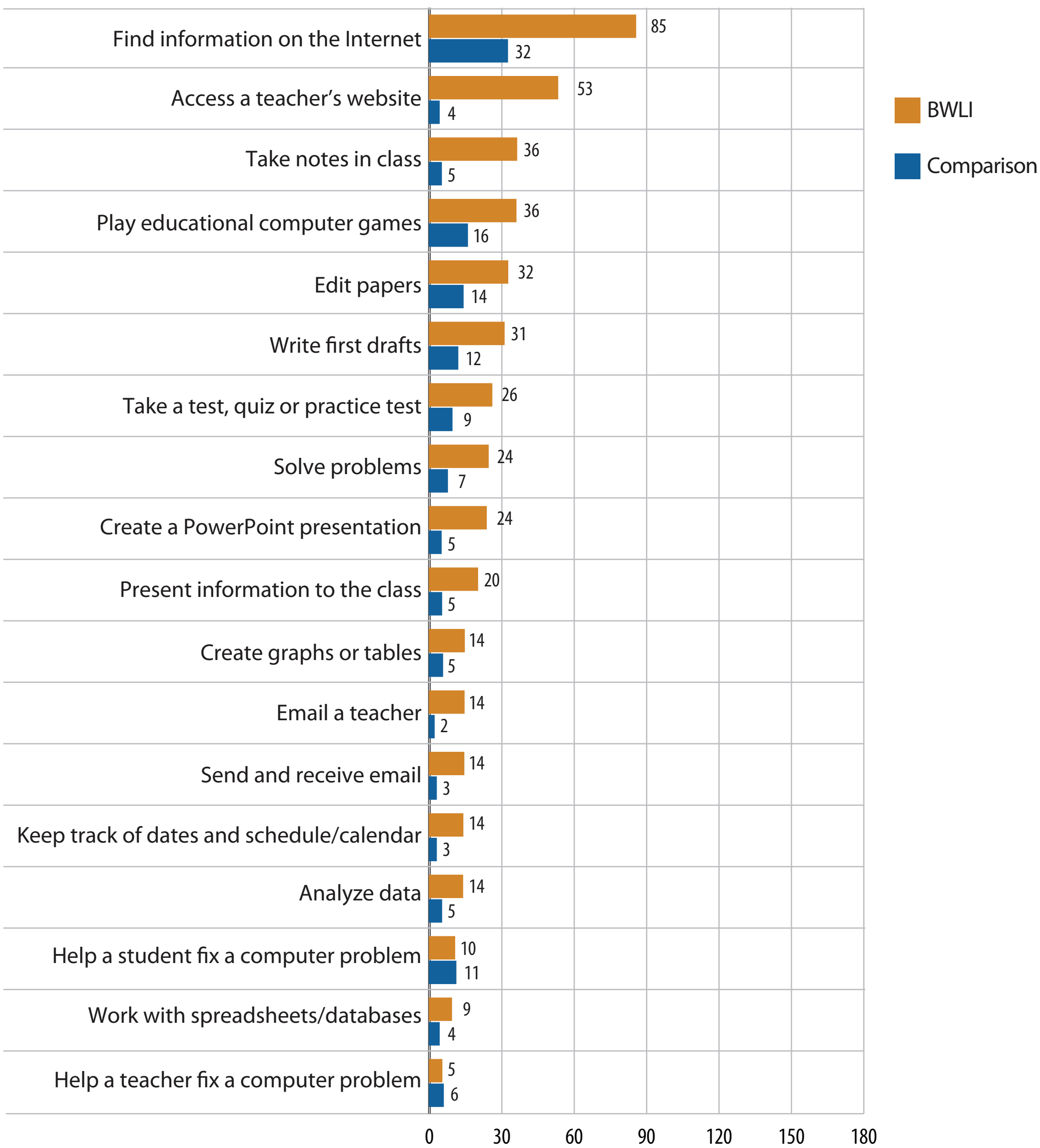


Figure 2 shows specifically the number of days during the third year of the 1:1 pilot implementation (2007–2008 school year) that students reported a variety of specific technology uses. Summarizing across all schools and grade levels, this table provides an estimate of the frequency of these specific types of technology across the five pilot and two comparison schools. As Figure 2 shows, pilot students used technology across a wide variety of applications and with substantially greater frequency than students in the comparison schools. In fact all differences are statistically significant at $p < .0005$, except "Help a student fix a computer problem" ($p = .546$) and "Help a teacher fix a computer problem" ($p = .648$).

The figure also allows for the comparison of the most-frequently occurring technology uses (found at the top of the figure) to the least frequently occurring uses (found at the bottom of the figure). By far, the most frequently reported technology use at both pilot and comparison schools was using a computer "to find information on the Internet." Other frequent uses of technology in the 1:1 settings included using a computer to: "access a teacher's web site", "play computer games", "take notes in class" and "edit papers using a computer." Some of the least frequent in-school technology uses during the 2007–2008 school year included using a computer to "analyze data", and "work with spreadsheets/databases."

Certainly, in each pilot setting students' access to digital resources and tools increased exponentially with 1:1 student computing. In both the classroom observations and teacher interviews, there were numerous accounts of how 1:1 computing and wireless Internet access had changed the way students' would access information and conduct research. It was generally observed that students' quick adoption and preference for the Internet (and more specifically Google) was emphatically reported to be the research tool of their choice. In the teacher survey, pilot teachers reported that once beginning the 1:1 environment they more frequently assigned their students to create products using a wider variety of tools and mediums than had been available prior to the 1:1 program. Specifically, teachers reported multifold increases in the frequency of their students creation of multimedia projects, pictures and art, stories and books, web pages or other web-based publications all using their new technology resources throughout the student laptop deployment. Teachers additionally observed that the increases in access to educational materials and tools for creating projects and products increased students' collection of skills. After the third scheduled year of program implementation over 60% of teacher respondents still felt that their students have "greater freedom of choice with regard to their individual learning style" due to their participation in the pilot program. Examining these results collectively, both the practices and sentiments of participating students and teachers suggest that students' markedly increased their access and use of technology to conduct research through participation in the 1:1 program.

There is also mixed evidence that student collaboration and interaction with peers increased with the resources and opportunities afforded to students through the 1:1 pilot program. Although a challenging outcome to measure, teachers across the pilot setting generally observed increases in student collaboration for a sizable portion of their students, although not the majority. Specifically, in the final survey pilot teachers reported that their students' interactions with other students had increased as a result of 1:1 computing. Across all 1:1 teacher respondents, 44% reported increased student interaction for their traditional students, 42% for their low-achieving students, and 39% for their high-achieving students. Across all types of students, fewer than 7% of teachers reported decreases in student peer interaction as a result of the 1:1 initiative. The post-BWLI principal/school leadership interview also saw school leaders divided in their assessment that "students interact with each other more while working with computers" where 3 of respondents agreed (40%) or strongly agreed (20%) and 2 disagreed (40%). However, teachers were stronger in their assessment that the BWLI program had positively impacted students' ability to work independently. For example in the final year-end survey, BWLI teachers largely reported that their students' ability to work independently had increased as a result of the program. Across all 1:1 teacher respondents, 69% reported increases in their traditional students ability to work independently, 65% for low-achieving students, and 52% for high-achieving students (less than 3% reported declines). Based on this evidence, we can conclude that both student collaboration and interaction increased for many 1:1 students and in many pilot classrooms, but the impact of the initiative on student collaboration was much less dramatic and universal than many of the other study findings.

Enhanced Student Achievement

After three years of 1:1 implementation there was evidence that student achievement had been positively enhanced through the types of educational access and opportunities afforded by the 1:1 pilot program. In the following exploration of student achievement, we highlight results using a variety of approaches and perspectives including:

- teachers and school leadership attitudes and beliefs concerning the impact of 1:1 computing on their students' academic achievement,
- achievement trends in schools' overall MCAS performance over time compared to the comparison schools and state trends,
- which, if any, of students' technology uses in school or home relate to student-level performance on various MCAS outcomes (while statistically controlling for students' pre-BWLI academic performance using prior MCAS performance), and

- the results of a computer-writing study whereby BWLI seventh grade students completed an extended writing exercise with and without technology.

Each of these approaches and perspectives for examining student achievement has their own focus as well as methodological limitations. So, we summarize each approach individually to provide readers a broad spectrum of results from our achievement inquiry as well as to provide an indication of the complexity and challenges associated with each approach.

Teacher Attitudes Towards 1:1 Computing and Its Impact on Students' Academic Achievement

In a series of five-point Likert scaled survey questions (Strongly Agree, Agree, Neither Agree/Disagree, Disagree, and Strongly Disagree) teacher attitudes and beliefs towards the 1:1 pilot program were addressed after three years of participation in the June 2008 survey. Table 7 begins the summary of teacher attitudes towards 1:1 computing by addressing the degree to which teachers feel the laptop program has impacted their students.

Table 7: Summary of Pilot Teacher Sentiments Towards 1:1 Computing

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
My students have benefited greatly from participation in the 1:1 laptop program.	34%	37%	25%	3%	1%
I would encourage other Massachusetts middle schools to adopt 1:1 computing programs.	31%	37%	21%	8%	4%
The considerable costs and expenses associated with 1:1 laptop programs are not justified based on my experiences.	6%	17%	27%	25%	25%
The impacts of any 1:1 computing program may take many years to be fully understood.	16%	46%	25%	9%	4%

As Table 7 shows, after three years of program participation, teachers were largely positive in their sentiment and attitude towards 1:1 computing. Overall, 71% of BWLI teachers felt that their students had "benefited greatly" from their participation in the 1:1 program. In contrast, only a very small portion of teachers (4% total) disagreed with the statement that students had greatly benefited from their participation in the

1:1 laptop program. When teachers were asked more pointedly, about "encouraging other Massachusetts middle schools to adopt 1:1 computing" teachers were nearly as positive with 68% of participants in agreement. Half (50%) of all pilot teachers reported that they disagreed or strongly disagreed with the surveyed statement indicating that the considerable costs and expenses associated with a 1:1 laptop program is indeed justified based on their own experiences. Amongst the remaining half of teacher who did not expressly feel the expenses were justified, 23% agreed the costs and expenses were not justifiable while 27% reported that they could neither agree nor disagree with the statement. It is also highly noteworthy to policy makers and educators alike that the majority of 1:1 teachers (60%) agreed with the survey item stating the "impacts of any 1:1 computing program may take many years to be fully understood."

Teachers were also presented a list of fourteen types of student behaviors, attitudes, and activities and were asked to rate how such actions have changed (Declined, No Effect, Improved) since the laptop program was first launched. Teachers were asked to focus the responses to these survey items based on specific groups of students. These groups included:

- high achieving students,
- at-risk or low-achieving students, and
- traditional students

The results reported below are averaged from all of the 108 BWLI primary subject teachers who completed the final June 2008 survey. Figure 3, below presents 1:1 teachers' beliefs on the impacts of 1:1 computing following three years of participation in the pilot program.

Figure 3: Teachers' Beliefs on the Impact of 1:1 Computing Across Different Students (June 2008)

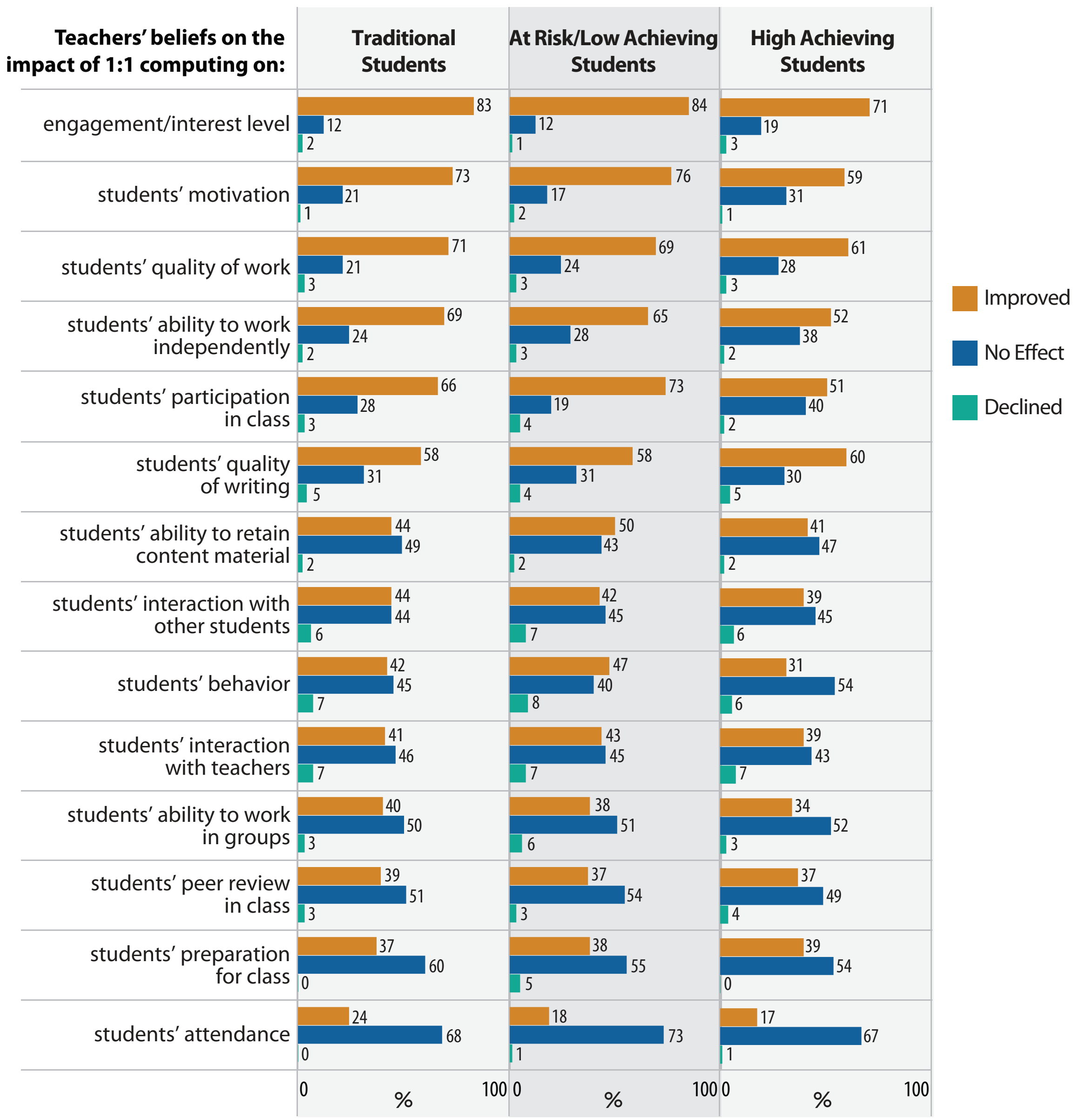


Figure 3 illustrates teachers' beliefs on the impact of 1:1 computing across a wide variety of student behaviors, attitudes, and activities for their traditional, high-achieving, and low-achieving students. The fourteen student outcomes are sorted and organized by the degree of teacher sentiment, such that areas where teachers have observed the greatest improvements are located in the top of the figure, while areas with the least improvements are located at the bottom. Although a great deal of information is contained within Figure 3, even a casual glance reveals that substantially more participating classroom teachers had a positive overall assessment of the 1:1 outcomes than negative or neutral. After two or more years' experience in a 1:1 setting, teachers reported improvements were most concentrated in their students' interest/engagement in class, motivation, and quality of work. In addition, the majority of teachers expressed that the program had also served to improve the quality of their students' work. This observation was found across all three types of student groupings. However, the category with the highest percent of improvement was found for traditional students with 71% of 1:1 teachers reporting that students' quality of work improved compared to 69% for at-risk/low achieving students and 61% for high achieving students. More specifically, the survey also addressed the impact on more specific student outcomes, such as the quality of student writing. High achieving students' writing quality was seen to benefit most from the 1:1 laptops with nearly 60% of teachers responding that their high-achieving students' writing quality had improved, although at-risk/low achieving students and traditional students were seen to improve by nearly as many teachers. Conversely, a small number of teachers (under 5% for each category) felt that their students' writing had declined as a result of the 1:1 program.

Principal and School Leaders' Attitudes Towards Students' Academic Achievement

In their final research interview, after three years of 1:1 computing, each principal/school leader (n = 5) was presented with a number of statements addressing the potential impacts of the 1:1 pilot program. School leaders were asked to rate their degree of agreement with each statement using only the following scale: Strongly Agree, Agree, Disagree, Strongly Disagree. Responses were recorded during the interview and are reproduced in Tables 8 (next page) and 9 (page 30).

Table 8: Summary of General Attitudes and Benefits of Computers in Education Across BWLI Principal/School Leaders (2008 Interview)

	Strongly agree	Agree	Disagree	Strongly disagree
Students are more willing to write second drafts when using a computer.	100%	0%	0%	0%
Students would use technology more at my school if there was less pressure to perform on standardized tests.	67%	33%	0%	0%
Students create better-looking products with computers than with other traditional media.	60%	40%	0%	0%
Students work harder at their assignments when they use computers.	20%	60%	20%	0%
Students interact with each other more while working with computers.	20%	40%	40%	0%
Computers help students grasp difficult curricular concepts.	0%	100%	0%	0%
Students develop a deeper understanding of the subject material when using a computer.	0%	80%	20%	0%

Table 8 shows the BWLI schools' leadership was overwhelmingly positive in their views towards most of the commonly ascribed positive student outcomes from the 1:1 literature. For example, all of the interviewed school leadership reported unanimously that their students were "more willing to write second drafts when using a computer." One hundred percent of all interviewed school leaders also believed that computers helped their students "grasp difficult curricular concepts" and allowed them to "create better looking products." Moreover, of the school leaders who responded to this question, all were unanimous in their belief that "students would use technology more at my school if there was less pressure to perform on standardized tests." There was only one school principal/leader who disagreed with the sentiments of the other four pilot school leaders who reported that their "students develop a deeper understanding of the subject material when using a computer" and that "students work harder when using a computer." In addition to these general statements concerning the impact of computers on education, the interview also queried principals and school leaders to reflect on more specific items about the implementation and impacts of the pilot program specifically. These results are shared in Table 9 (next page).

Table 9: Summary of Specific Attitudes and Benefits of the 1:1 Pilot Program Across BWLI Principals/School Leaders (2008 Interview)

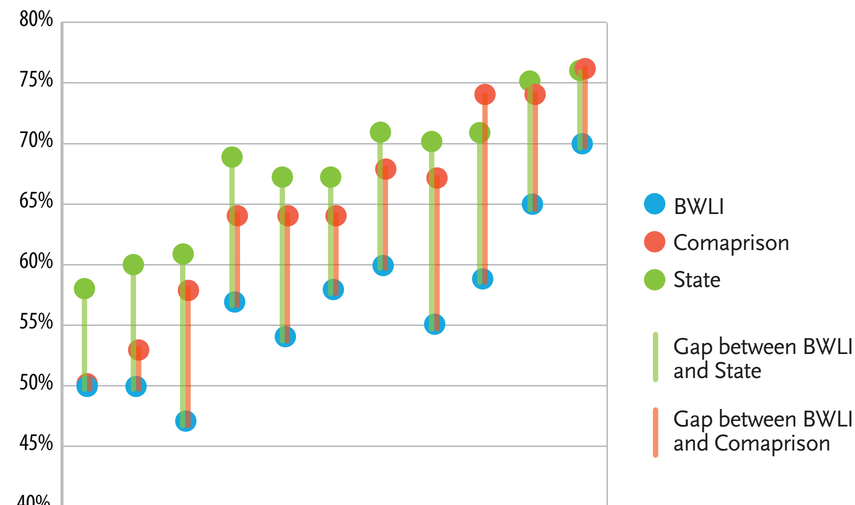
	Strongly agree	Agree	Disagree	Strongly disagree
The BWLI program has positively impacted my students' academic performance.	75%	25%	0%	0%
Increased technical support could have improved the effectiveness of the BWLI program.	60%	40%	0%	0%
The BWLI program has positively impacted my students in non-academic ways.	50%	25%	25%	0%
The impacts of any 1:1 computing program may take many years to be fully understood.	40%	60%	0%	0%
My students have benefited greatly from their participation in the 1:1 laptop program.	40%	40%	20%	0%
My teachers' teaching has improved as a result of the 1:1 laptop program.	40%	40%	20%	0%
I would encourage other Massachusetts middle schools to adopt 1:1 computing programs.	40%	40%	20%	0%
Increased curriculum support could have improved the effectiveness of the BWLI program.	20%	60%	20%	0%
The considerable costs and expenses associated with 1:1 laptop programs are not justified based on my experiences.	0%	40%	40%	20%

Table 9 shows that the views of the 1:1 pilot school leadership were again overwhelmingly positive in their attitudes towards outcomes of 1:1 computing. For example, all (100%) of the interviewed school leadership reported that the "BWLI program has positively impacted my students' academic achievement." Again, there was only one school principal/leader who disagreed with the sentiments of other four pilot school leaders who reported that "The BWLI program had positively impacted my student's in non-academic ways" and "my students have benefited greatly from their participation in the laptop program." Similarly, in the interview questions weighing the costs and benefits of the pilot program, again the same school leader disagreed with the others who expressed universal agreement with the statement "I would encourage other Massachusetts middle schools to adopt 1:1 computing programs." An additional school leader expressed some trepidation in a second (and more pointed) question concerning the costs and benefits associated with 1:1 computing. In total 60% of 1:1 pilot school leaders disagreed with the statement "considerable costs and expenses associated with 1:1 laptop programs are not justified based on my experiences" while 40% expressed agreement.

School-Level Trend Analyses

In this series of analyses, student pass rates on the MCAS were weighted and averaged across the three public BWLI schools and compared to the combined student performance in the two comparison settings as well as to statewide student performance for both seventh grade and eighth grade achievement trends. For example, Figure 4 shows the percent of "passing" students on the 8th grade Math MCAS for BWLI schools, comparison schools, and the average state pass rates from 1998 to 2008.

Figure 4: Percent of Students "Passing" 8th Grade Math MCAS (1998–2008)



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
BWLI	50%	50%	47%	57%	54%	58%	60%	55%	59%	65%	70%
Comaprison	50%	53%	58%	64%	64%	64%	68%	67%	74%	74%	76%
State	58%	60%	61%	69%	67%	67%	71%	70%	71%	75%	76%
GAP: BWLI / State	-7.5%	-10%	-13.5%	-11.8%	-12.8%	-9%	-11.3%	-15.3%	-12.2%	-9.8%	-6.3%
GAP: BWLI / Comparison	0.5%	-3%	-10.5%	-6.9%	-9.5%	-5.7%	-8%	-12.1%	-15.1%	-8.9%	-6.7%

Figure 4 shows the percent of BWLI students, comparison students, and the state average of students who passed the 8th grade Math MCAS each year from 1998 to 2008. With the first MCAS assessment in 1998 both BWLI and comparison schools' pass rates were 50% on average, 8% below the state average of 58%. Over the next seven years (the pre-BWLI period) scores in the comparison setting rose, steadily eliminating their performance gap with the state average. In this same time, BWLI scores also increased although less dramatically so that by the 2005 and 2006 assessments, BWLI pass rates were increasingly lagging behind both comparison schools and state averages. In 2006, the overall pass rate for the 8th grade Math MCAS was 59% in the BWLI settings compared to 74% in the comparison schools and 71% statewide.

The Spring 2007 MCAS assessment represents the first time the 8th grade student cohort had 1:1 laptop access including most of their 8th grade year as well as the last half of their 7th grade year across the BWLI schools. This cohort of BWLI students showed strong progress in improving pass rates 5% during each year of the 8th grade BWLI implementation, bringing the average pass rate up to 70% by 2008. In other words, this unprecedented two-year improvement in eighth grade Math pass rates across BWLI settings corresponded with the years students' participated in the 1:1 laptop program.

Similarly, additional examinations of 7th grade school performance on the ELA and Math MCAS found the highest student pass rates in 2007, the first full year of the BWLI implementation in grade 7 and the year when students and teachers reported the most widespread and frequent use of technology in the respective surveys. Specifically, grade 7 student performance in the BWLI settings reached its highest historical levels on record for both the ELA (since 2001) and Math (since 2006) MCAS during the year when BWLI implementation and use was at its peak. Similarly, our examination of test results for 8th grade performance on the ELA, Math, and Science MCAS also found the highest levels of student achievement were observed in 2007 and/or 2008, the two years that the BWLI implementation provided 1:1 laptops to grade 8 students. Like the patterns observed for the 7th grade assessments, grade 8 student performance in the BWLI settings reached its highest historical levels in every tested subject area (ELA, Math, and Science) when the BWLI implementation and use were at their peak.

Without a true experimental design, this trend analyses does little to prove that the 1:1 pilot program improved test scores. However one potential explanation of the seventh and eighth grade MCAS pass rates over this time period could be that 1:1 participation was conducive or complementary to practices that fostered improvements in test performance. Given that each year of our MCAS analyses represents different cohorts of students, there is a possibility that the improvements realized during the 1:1 implementation years may also be attributed (in full or part) to pre-existing characteristics of the student body that completed the exam in 2007 and 2008. Although it seems fairly unlikely that the years of the full 1:1 laptop implementation also witnessed better performing students in each of the BWLI schools than had existed historically, without a randomized experimental study it is impossible to completely attribute these test score gains to the 1:1 pilot program. However, it is possible to examine the potential of any "cohort effect" within these results through further examination of how individual student performance on the MCAS has changed during the BWLI implementation period. In other words, how much improvement, if any, was observed for 8th grade students' test performance after two years of 1:1 computing compared to the same students two years earlier in grade 6.

Student-level Relationship Between Achievement and Technology Use

As previously summarized in the methodology section, a student level data set was created that included MCAS results as well as the final administration of the student survey (June 2008). Thus, for each student who completed the MCAS and the BWLI survey, the relationship between student achievement and participation in 1:1 computing activities can be examined. Table 10 provides demographic information from the newly merged 2007–2008 MCAS/BWLI data set across the eighth grade BWLI and comparison school settings.

Table 10: Demographic and MCAS Information for Pilot and Comparison Students (Spring 2008)

	Conte	Herberg	Reid	North	South
% of Students eligible for free/reduced lunch	44%	38%	57%	26%	45%
% of non-white (A, B, H, M, N) students	16%	18%	24%	10%	20%
Mean ELA raw score	34.6	35.6	34.8	36.7	34.5
Mean Math raw score	31.4	31.9	29.7	33.7	30.5
# of Students who completed 2008 MCAS	116	268	219	237	238
# of Students who completed 2008 BWLI survey	115	253	211	172	177
# of Special education students	21	43	34	42	43

Table 10 shows the mean MCAS scores across each school's 2008 eighth grade class, the percent of students who were eligible to receive free or reduced lunch, the percent of non-white students, the number of special education students, as well as the number of students who completed the final Year 3 BWLI survey in June 2008.

Exploratory data analyses were performed using the student data to investigate if the frequency of teachers' and students' various technology uses (as measured by the student survey) exhibited any notable relationship with the 2008 student achievement results. More simply put, did any of students' specific uses of technology during the third year of the 1:1 pilot program relate to their test performance? Given the fact that there was such wide variation across and between the 1:1 and comparison school students, the current data set provides a good opportunity for such explorations particularly considering the high participation rate.

Because there were such a wide ranging number of surveyed student technology uses, factor analysis was applied across the student survey items to create more reliable and stable measures of student practices within the 1:1 and comparison school settings. Specifically, principal component analysis was applied to create six scales representing different types of student technology use for writing and research, solving problems, presenting information, class-related activities, communicating, and reported teachers' use of technology. Four additional scales were created from the student survey results to represent students' varied home use of computers including writing and research, multimedia, communication and social use, and recreational use. Lastly, student attitudes and beliefs were summarized across survey items to form two scales concerning students' beliefs towards 1:1 computing and students' self-perception of their technology abilities. Additional information on the factor analyses and student technology use scales is available in the Final BWLI Evaluation Report (Bebell & Kay, 2009) at: www.bc.edu/bwli.

Through an analysis of student test performance and various indicators of technology practices, it is possible to get some general understanding of the complex relationship between student and teacher practices and student achievement (as measured by the MCAS). In this type of design (including students from non-1:1 laptop settings in comparison groups) it is possible to examine if specific technology practices appear to be relating to test scores positively, negatively, or not at all. In the following analyses, the relationship between teachers' and students' use of technology and MCAS performance is demonstrated using Pearson's correlation coefficients *(r)*. For the correlation tables of student results presented below, correlation values found to be statistically significant are depicted in bold ($p < .05$, 2-tailed test). Again, these correlation results are not intended to determine the effectiveness of the 1:1 pilot program or its various components, but rather to explore what student and teacher uses may be related to a common measure of student achievement. Table 11 (next page) shows the correlational relationship between 8th grade students' 2008 performance on the ELA, Math, and Science sections of the MCAS with socioeconomic status indicators and commonly reported technology uses.

Table 11: Correlations Between 8th Grade Students' 2008 MCAS Performance and Commonly Reported Technology Uses

	BWLI		Comparison	
	ELA	Math	ELA	Math
ELA raw score		**.68**		**.68**
Math raw score	**.68**		**.68**	
ELA raw score 2007 (6th grade)	**.78**	**.70**	**.78**	**.68**
Math raw score 2007 (6th grade)	**.67**	**.86**	**.68**	**.87**
Socio-economic status	**.34**	**.38**	**.40**	**.37**
Student use in school				
In the past year, how often did you use technology in your classroom?	**.08**	**.16**	**–.40**	**–.19**
Student computer use in Reading/ELA	.02	**.12**	**–.36**	**–.23**
Student computer use in Social Studies	–.02	–.04	**–.20**	**–.15**
Student computer use in Math	–.06	.02	**–.29**	**–.20**
Student computer use in Science	.02	**.15**	**–.27**	**–.18**
Writing and research	.05	**.10**	**–.24**	**–.17**
Solve problems	–.04	–.01	–.07	–.04
Present information	**–.08**	**–.05**	–.11	–.05
Class-related activities	–.08	–.09	**–.17**	–.08
Teacher use of computers	.04	**.09**	–.02	.01
Communication	–.04	–.01	–.07	–.04
Uses at home				
Writing and research	–.06	–.09	.01	–.04
Multimedia use	**.10**	.01	.02	.05
Communication	.06	.03	.02	.03
Recreational home use	**.10**	.01	.03	.03
Technology beliefs	–.03	–.01	.07	.04
Self-perceived abilities	.02	.06	–.03	.01

Note: Bold correlations represent statistical significance at the .05 level (2 tail)

Overall, it appears that there are a number of student level indicators (including students' and teachers' technology uses measured by the Spring 2008 survey) which were found to have a statistically significant relationship with student achievement as measured by the Spring 2008 MCAS. It is noteworthy that for both the comparison school sample and the BWLI sample, the relationship among the 2008 tested subjects (ELA, Math, and Science) exhibited strong positive correlations (between .69 and .80) indicating that students' performance on one section of the MCAS was highly indicative of their performance in other tested subject areas. In addition, there was a very strong statistically significant relationship between students' 2008 8th grade MCAS performance and their prior performance on MCAS, particularly in Math where correlations were observed as high as .87. Similarly, students' socio-economic status (SES), as measured by a scale incorporating a student's participation in free or reduced lunch programs and the number of books a student has at home as reported on the student survey, was positively correlated with MCAS performance indicating that low-SES students received lower test scores than students who were not eligible for assistance programs. In addition, the relationship between past achievement and student home variables on test performance has a long history in educational research and testing, and the results presented here echo much of this literature. Clearly, the very large positive correlations observed across students' 2007 and 2008 test performance show that students prior test performance is the major predictor of future performance, independent of setting, educational reforms, or practices.

In terms of the relationship between students' use of technology in the classroom and test performance, statistically significant (yet fairly weak) positive results were found for the BWLI eighth grade students (who had about two years of 1:1 laptop use in school) while statistically significant negative results were found for the comparison school 7th grade students (who never participated in a 1:1 laptop program). Specifically, 1:1 pilot students who reported using technology in their classroom during the 2007–2008 school year more frequently were found to score better on both the Math and Science 8th grade assessment than those 1:1 students who did not report as frequent use. In the comparison settings, the relationship between technology use in the classroom and ELA and Math performance also exhibited a statistically significant correlation, however the relationship was negative.

Also presented in Table 11 is the relationship between the frequency of students' reported use of technology across their four primary classes (ELA/Reading, Math, Social Studies, and Science) and 2008 MCAS performance. The relationship between BWLI test performance and students' subject specific technology use varied by subject area, however statistically significant relationships were observed for ELA, Math, and Science.

Student use of computers in Social Studies and Science classes was negatively correlated with MCAS ELA scores across BWLI students. Conversely, student use of computers in Reading/ELA and Math classes was positively correlated with Math and Science MCAS performance in the 1:1 pilot settings. For the comparison students, the relationship between student use of technology across the core curricular subjects and MCAS performance was again entirely negative. Statistically significant correlations were observed for students' use of computers in Reading/ELA and student performance in ELA and Science, suggesting that the types of computer activities in non-1:1 settings were not necessarily conducive to increased student test performance.

Lastly, Table 11 includes a summary of correlations between scales of specific student uses of technology in school and ELA, Math, and Science MCAS scores. As shown above, nearly all of the specific technology uses exhibited weak, negative correlations with test results both for 1:1 pilot students and comparison school students. These results suggest that the specific skills gained by students who frequently use these technology applications in school may be unrelated or even negatively related with MCAS performance. Again, in this analysis we see BWLI students experiencing somewhat more positive impacts from their use of technology than comparison students in the non-1:1 setting where nearly all specific school uses were negatively correlated with test performance. Specifically, for the BWLI eighth grade students, statistically significant positive correlations were observed for students' in school use of technology for "communication" with their 2008 Math and Science performance. Two statistically significant negative correlations were additionally observed; for BWLI students' use of technology in school to "present information in class" with ELA and Math performance and "in class activities" with Science. In addition, 1:1 pilot students' frequency of home use of computers for "recreational use" was observed to be a positive statistically significant predictor for ELA and Math raw scores, whereas multimedia use was a negative statistically significant predictor in the non-1:1 settings. Lastly, students' technology beliefs towards the 1:1 program were not found to be a statistically significant predictor of MCAS performance in BWLI or comparison settings, however in the 1:1 setting students perceived abilities to use technology exhibited a statistically significant correlation with students MCAS performance across all tested subjects.

Determining the Relationship Between Student-level Technology Use and Student Achievement

In the preceding tables and figures, the relationship between students' use of technology and measures of student achievement were explored for BWLI and comparison school students. Through these exploratory analyses of potential variables that may impact students' achievement, previous achievement on prior MCAS exams was clearly the largest and most substantial predictor of students' performance on the 2008 assessments. In addition, students' socio-economic status was also a consistently strong predictor of all student achievement measures. Of more interest to the current inquiry, a number of student technology use indicators were also found to be statistically significant predictors of different student achievement measures. However, given the overall weakness of these correlations and that prior MCAS performance is such a strong predictor of current and future achievement, does participation in the 1:1 pilot program still have an impact on student achievement after the large effects of prior achievement are statistically controlled? In other words, did being in the 1:1 pilot program and using technology in school results in student test performance beyond what we would expect for students given their past performance? The following analyses of 8th grade 2008 1:1 pilot and comparison student participants seek to address this question.

Again, all eighth grade BWLI students completed the ELA and Math MCAS in Spring 2008 after nearly two full years of participation in 1:1 learning environments. The Spring 2006 MCAS assessment (completed by these same students when they were in grade 6) represents the last available state assessment results before students were exposed to the 1:1 setting, and given that both ELA and Math subject exams were offered, provides a good subject-specific measure of pre-laptop student achievement. Figure 5 shows average 2006 and 2008 MCAS raw scores for BWLI and comparison students.

Figure 5: Mean 2008 ELA and Math Raw Scores for 8th Grade BWLI and Comparison Students Compared to Their 2006 MCAS Raw Scores

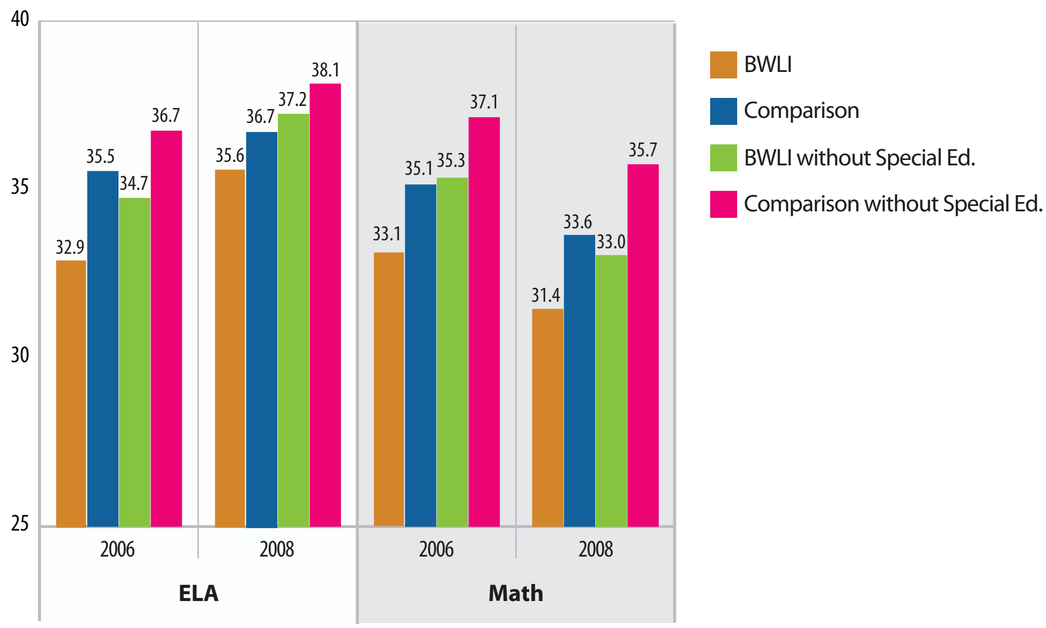


Figure 5 illustrates the mean ELA and Math MCAS performance for 8th grade students in 2008, compared to the same students' performance on the grade 6 ELA and Math MCAS in 2006. The figure shows the averages for BWLI students, who had approximately two years experience in a 1:1 environment, as well as for comparison students from two similar schools where no laptop program was present; although teacher use of technology was notably widespread in both comparison settings. Compared to their 6th grade test performance in 2006, 8th grade BWLI students averaged about 2.7 points better on the 8th grade assessment with a mean raw score of 35.6. Students in the comparison schools also improved in the 2008 assessment, although to a lesser extent than BWLI students with only a 1.3 point difference. However, comparison school students scored higher on average than BWLI students in both assessments. Although 11% more students "passed" the MCAS Math exam in BWLI schools in 2008 than had in 2006, the average of BWLI students' raw scores decreased from 33.1 in 2006 to 31.4 in 2008, a mean drop of 1.7 points. During this same period in the comparison schools, the average 8th grade student also scored 1.4 points lower on the 2008 MCAS Math assessment than they had two years previously on the 2006 MCAS Math assessment. As also observed for ELA performance, school averages were higher for the comparison students on both the 2006 and 2008 tests than across the BWLI settings. Lastly, Figure 5 additionally shows the average performance for 1:1 and comparison school populations with the 143 Special Education students excluded from the analyses. The observed net gains in 2008 scores for BWLI students were diminished in both the ELA and Math subject tests when the special education students were excluded from the statistical analyses. In other words, the 1:1 population as a whole saw larger net gains in both ELA and Math when special education students were kept in the 2006 and 2008 test analyses.

To summarize, pilot students averaged a net gain in ELA scores during their two years of 1:1 laptop experience. However, so did the students in the comparison group who had only limited computer access and resources. In Math, BWLI students' averaged lower scores on the 2008 assessment after two years of 1:1 computing (a net loss), but then again, so did the students in the comparison schools. So, to better determine if the impact on student achievement over the two years of 1:1 participation for the 8th grade pilot students was greater than the differences observed for comparison school students during the same time period, we will statistically assess how much of the net change in student performance can be possibly attributed to 1:1 participation and experiences.

Student level regression models were created for ELA and Math 2008 scores using nearly all 8th grade 1:1 and comparison students. Models were developed and analyzed to determine the overall program effect (i.e.

1:1 status) of BWLI participation on students' test scores. Thus, the ELA regression model included 2008 MCAS ELA raw scores as the dependent variable, BWLI status as an independent variable, and 2006 MCAS ELA raw scores as a controlling variable. BWLI status was a dichotomous variable with 1 representing a 1:1 pilot participant and 0 representing a comparison school student. The resulting equation for the 2008 8th grade ELA model was:

Predicted 2008 ELA MCAS = 0.764*(2006 ELA MCAS)* + 1.04*(BWLI Status)* + 9.83

The analyses found that the coefficients for both prior achievement (i.e. 2006 ELA score) and participation in the pilot program were statistically significant ($p < .0005$ for the ELA 2006 and $p = .006$ for BWLI). In other words, the increase in ELA scores for 1:1 pilot students was statistically significant compared to the increase in scores observed for comparison students. Thus, after controlling for prior achievement we can conclude that the statistically significant difference observed in 1:1 pilot students' 2008 ELA test performance was not present for the comparison students.

In addition, the current analyses also sought to look more specifically at the relationship, if any, between BWLI students' use of computers during their 8th grade year and their 2008 ELA performance. To this end, any of the student technology use variables that had statistically significant correlations with the ELA MCAS scores (Table 11) were entered into the 2008 ELA achievement regression model. Specifically, the following technology use variables and scales were examined:

- Student computer use in Social Studies
- Student computer use in Science
- Present information using computers scale (present)
- Recreational home use scale (recreation)
- Student perceived abilities scale (ability)

The resulting regression equation was:

Predicted 2008 ELA MCAS = 0.76*(2006 ELA MCAS)* – 0.004*(use in Social Studies)* – 0.018*(use in Science)* + 0.238*(present)* + 0.62*(recreation)* + 0.23*(ability)* + 12.12

Overall, this model accounted for 61% of the variance in 2008 ELA scores across all 1:1 8th grade students, however a great deal of this variance was explained solely by the 2006 scores. Specifically, after accounting for prior MCAS scores ($p < .0005$) two of the student technology-use predictors: *student computer use in science class* ($p = .003$) and *student recreation* *home use of computers* (p = .013) were observed to exhibit statistically significant coefficients.

First, a negative statistically significant relationship was found between students' frequency of computer use in Science class and their ELA achievement, even after controlling for past achievement levels and all other variables within the model. In other words, students who reported more frequent use of computers in their Science classes were found to be actually less likely to perform better on the 2008 ELA MCAS then those students who used technology less frequently in Science during their 2007–2008 8^{th} grade year.

In addition, a positive statistically significant relationship was also found between students' recreational home use of computers and their ELA achievement, even after controlling for past achievement levels. In other words, students who reported more frequent use of computers for recreation at home were actually more likely to perform better on the 2008 ELA MCAS than those students who used technology less frequently for recreation at home. To provide a clearer idea of what types of student computer uses comprised the recreational home use scale, the original four survey items comprising the scale included students' use of a computer to search the Internet for fun, create music or video projects, download music or videos, and shop online. Given that student home access and use appeared largely independent of students' experience in 1:1 program, it was theorized that the relationship between recreational home use and ELA achievement may actually be an artifact of students' socio-economic status (SES), which was previously observed to be a major correlate of student level 2008 ELA MCAS performance. In fact, the impact and significance of students' recreation home use of computers was completely diminished when we statistically controlled students' socio-economic status, as measured by the SES scale. Thus, the positive impact associated with home recreational use and variance accounted for in the 2008 ELA model was a by-product of students' socio-economic status. This result suggests that when students' SES is statistically controlled, as well as their 2006 scores, there was no difference in the impacts of recreational home computer use on 2008 ELA achievement.

None of the other individual or scaled student technology uses were found to be statistically significant in the ELA model, once prior achievement scores were controlled.

Eighth grade student results were also examined for Math achievement. The Math regression model included 2008 MCAS Math raw scores as the dependent variable, BWLI status as an independent variable and 2006 MCAS Math raw scores as the controlling variable. Again, BWLI status was a dichotomous variable with 1 representing a 1:1 pilot participant and 0 representing a comparison school student. The resulting equation for the 2008 8th grade Math model was:

Predicted 2008 Math MCAS = 0.77*(2006 Math MCAS)* + 0.75*(BWLI Status)* + 7.05

As expected, students' prior MCAS scores continued to be a major statistically significant predictor variable of 2008 MCAS scores ($p < .0005$). However, students' participation in the pilot program was not a statistically significant predictor of the 2008 MCAS scores ($p = .086$), when students' prior (pre-1:1) scores were also taken into account, as had been observed for ELA performance. Thus, there was no statistically significant relationship found between students' participation in two years of a 1:1 computer program and Math standardized test performance.

In addition, the current analyses also sought to look more specifically at the relationship, if any, between BWLI students' use of computers and Math performance. To this end, any scales or variables that had significant correlations with the BWLI Math MCAS scores (Table 11) were entered into the Math regression model below. In addition, since the correlation between BWLI students' 2008 MCAS Math performance and multimedia home use was very close to statistically significant, it was included in regression model as well. In total, the following technology use variables and scales were examined:

- Student computer use in Reading/ELA
- Student computer use in Math
- Writing and research at school scale (writing)
- Present information using computers scale (present)
- Multimedia use at home scale (multimedia)
- Recreational home use scale (recreation)
- Student perceived abilities scale (ability)

The resulting regression equation was:

Predicted 2008 Math MCAS = 0.85*(2006 Math MCAS)* + 0.016*(use in Reading/ELA)* + 0.028*(use in Math)* – 0.304*(writing)* – 0.289*(present)* + 0.528*(multimedia)* + 0.607*(recreation)* + 0.030*(ability)* + 2.79

Overall, this model accounted for 43% of the variance in 2008 Math scores across all BWLI 8th grade students, however the great majority of this variance was explained solely by the prior test scores. Specifically, across all of these predictor variables, only the 2006 Math raw scores ($p < .0005$) was found to be a statistically significant predictor. The variable *student use of computers in Math class* approximated a statistically significant coefficient with 2008 Math performance outcomes (p =. 09), but fell just outside the established criteria for statistical significance.

In conclusion, the statistical analyses of student-level MCAS results revealed some positive, yet far from conclusive, results on the impacts of the 1:1 pilot program on student learning as measured by the state standardized assessment. In terms of overall program impacts, 1:1 student score increases across 1:1 settings were found to be statistically greater than increases in the non-1:1 settings for ELA achievement but not for Math during the final two years of the 1:1 implementation. When examining the specific relationships between the pilot students use of technology in school and at home, nearly all of the individual and scaled technology use measures failed to result in statistically significant relationship on the ELA or Math scores, once student prior achievement was accounted for.

In this analysis of school level and student achievement data, we have explored the impact of 1:1 participation on student achievement using the state standardized assessment as a common metric of student performance across 1:1 and comparison settings. However, the educational technology literature and the models themselves suggest that perhaps the MCAS may not be the most sensitive or appropriate measure of student achievement in the 1:1 settings. To more fully explore the limitations of the MCAS as an outcome measure, we conclude our analyses of student achievement with the results of a randomized computer writing study conducted across all seventh grade 1:1 pilot classrooms in Spring 2008.

Computer Writing Study Results

In an attempt to get a better understanding of the relationship of 1:1 computing and student technology uses on student achievement, the research team devised and carried out a study of students' writing ability. As summarized in the Methodology section, the BWLI computer writing study randomly assigned all 7th grade 1:1 students to complete a realistic MCAS extended writing test over two 45-minute sessions in Spring 2008. A total of 388 essays were collected from students in the "computer" environment while 141 essays were collected on paper before being transcribed and scored by a team of trained readers. A summary of student performance across the computer and paper testing conditions is presented below in Table 13 (next page).

Table 13: Comparison of 7th Grade Results for Students Completing an MCAS Essay Using Their Laptop or Traditional Paper/Pencil

	# of students	Topic Score	Conventions Score	Word Count
Computer	310	7.2	5.6	388
Paper	141	6.6	5.3	302

Table 13 shows after two years of 1:1 computing in school, 7th graders participating in the computer writing study wrote both longer and more highly scored open response essays when using their laptops than students responding to the same prompt using traditional paper and pencil. To control for any pre-existing differences between the computer and paper students, seventh grade open response scores from the "official" paper/pencil ELA MCAS (Spring 2008) were used as a covariate to account for students writing ability in a traditional testing environment. Using a general linear model, we statistically controlled for paper-tested writing scores while evaluating the impact of computer use in testing conditions that allowed students to use their laptop and word processor rather than paper and pencil.

When controlling for students' respective performances on the paper/pencil MCAS writing assessment, both the Topic Development and Standard English Conventions score difference observed between laptop students and paper/pencil students were found to be statistically significant. Specifically, after controlling for students' Topic Development score on the 2008 paper/pencil MCAS, students' Topic Development score was substantially higher for those students who completed the essay using their laptop than for the paper students ($F = 4.79$, sig. .029 Adjusted $r^2 = .203$). After controlling for Standard English Conventions score on the 2008 paper-based MCAS, students' Standard English Conventions score was also greater for those students who completed the essay using their laptop than for the paper students ($F = 4.67$, sig. .031, Adjusted $r^2 = .122$). Given these results, it is clear that pilot students, after using a laptop across their sixth and seventh grade years of middle school, performed better across both writing scales when allowed to complete the writing assessment using their BWLI computers.

Lastly, after controlling for Standard English Conventions score on the 2008 paper MCAS (word count is not counted on the official MCAS), the number of words students composed was still found to be substantially greater for those who completed the essay using their laptop than using traditional paper and pencil ($F = 19.95$, sig. $<.001$, Adjusted $r^2 = .256$). Specifically, students who completed the writing assessment using their laptop produced an average of 388 words compared to 302 words for the essays composed on paper across all BWLI settings.

These results highlight the challenges of measuring the impact of students and schools where technology has been adopted and widely used. These results also suggest that increasingly tech-savvy students may be at a considerable disadvantage to demonstrate their writing ability on official state assessments, which are exclusively paper and pencil. Obviously, further complications are likely when the paper/pencil state test results are used to demonstrate the effectiveness of investments and programs involving computer based technologies.

Discussion

> In school, it is important to keep kids informed and ready for the real world and the work force, and computers are becoming a very important part of our world. It is important that we know how to use a computer so that when we reach the workforce and higher levels of education, we are not struggling to keep up. Also, using computers in school is a great way to keep kids focused and ready to learn, and keep people interested in the education they are receiving. Computers, especially laptops, are our links to an ever-expanding world of technology, and it is important to know how to connect to this world easily, which having laptops allows us to do.
>
> –*8th grade Female Student*
> Herberg Middle School, Pittsfield, MA
> Comment on June 2008 student survey

As educational theorist and critic Larry Cuban and others have demonstrated, educational technology use in typical school environments (where technology resources are shared) has typically resulted in sporadic and limited use, particularly when considering teachers' direct instructional use and students' use (Cuban, 2001). Consequently perhaps, the impacts of various technologies in education have been slow to emerge. One of the earliest findings emerging from the pioneering 1:1 settings (the first 1:1 student laptop program was launched in 1989 in Sydney, Australia) was that teachers' and students' use of technology increased exponentially. This dramatic increase in computer use is obviously related to the increased access and resources when technology is no longer shared, as well as the leadership and vision of these early adopting educational settings. However, with technology actually being used with some regularity it is possible to begin to realistically assess how different uses may impact teaching and learning.

The purpose of the BWLI program and this subsequent research has been to determine the impacts of a 1:1 pilot program on reforming teaching and learning practices across five varied middle school settings. Although the implementation and outcomes across each participating school varied, it is clear from the current investigation that 1:1 computing holds major promise for impacting the lives of teachers and students in meaningful ways, which may lead to many positive outcomes. Specifically, the current investigation was principally concerned with documenting the four targeted program objectives identified before the pilot program was launched in 2005: fundamental shifts in teaching practices, enhanced student achievement, improved student engagement, and enhanced student research and collaboration. Of specific interest within our study has been the way teachers transformed their teaching practices to accommodate technology and how these changes enhanced student engagement and learning. Within this context, the various methodological approaches and subsequent statistical results reveal that teaching and learning were indeed impacted across the vast majority of pilot classrooms. However, as would be expected from any pilot program employed across dozens of classrooms in five unique middle school environments, the degree of adoption, use, and subsequent realization of positive outcomes varied across and within settings.

As summarized in the *Introduction* and *Background* sections of this paper, past research and evaluation on the impacts of 1:1 computing have generally focused on similar academic outcomes (Penuel, 2006). However, given that 1:1 computing is still in its infancy and that few of the largest programs have had serious resources invested in evaluation and research efforts, there is still a great deal to learn about 1:1 laptop computing programs. Like studies in New Hampshire (Bebell, 2005), Maine (Silvernail, 2008), Texas (Shapleigh, 2008), and Colorado (Zucker and Hug, 2008), the Massachusetts results from the pilot program suggest that 1:1 computing can dramatically and radically change teaching and learning practices. There is little question that the student and teacher laptops, in addition to the increased professional development, support, and organizational structure provided through the Berkshire Wireless Learning Initiative, truly changed teaching and learning conditions for the majority of students and teachers in these settings. Specifically, after three years of implementation we witnessed a marked change in teaching and learning in the participating schools. The consensus of the participants (school leaders, teachers, and students) was overwhelmingly positive towards these educational opportunities afforded through increased educational technology. As observed years earlier in the New Hampshire pilot program, it was very soon in the deployment process that teachers and students began incorporating technology into their lessons. This may suggest that 1) teachers and students felt ready for change and 2) the majority viewed educational technology as an improvement over existing practices.

The proponents of educational technology and 1:1 programs believe there is potential to radically change the teaching and learning practices (and even classroom structure) via the adoption and use of 1:1 computing, much the same way other areas of our culture (communication, entertainment, etc) have been transformed through PCs, e-commerce, and the Internet. Indeed, many of the early visionaries of the 1:1 computing "movement" have pointed to outcomes and results that go well beyond the scope of most educational initiatives. Maine Governor Angus King, who launched the nation's first statewide 1:1 laptop program, for example, promoted the *Maine Learning Technology Initiative* as an important component of Maine's economic development initiative. Educational theorist and author Seymour Papert argued over 30 years ago that providing students with powerful technologies could and will change the nature of how students actually think and retain information. Similarly, today's students, as evidenced by their frequency of home computer use, have quickly embraced computer technologies across numerous aspects of their lives. Indeed, students' expectations for computers and their seemingly natural abilities to assimilate technology are so great that it can even be disconcerting to teachers and parents. For example, the recent explosion in popularity of websites such as Facebook and mySpace for social networking and communication amongst middle and high school students cannot be exaggerated. Albeit the targeted objectives assessed in the current pilot program were somewhat more conservative by nature, 1:1 computing, given its ubiquitous nature and the ever-increasing power and adaptation of computing technologies, continues to represent a strong departure from the status quo and existing educational practices in most public middle schools. As documented specifically in the analyses of student and teacher practices and attitudes across the five pilot settings, not every teacher was willing or interested to experience a "radical shift" in their pedagogy and practices as the majority of their students seemed to be.

It is impossible to overstate the power of individual teachers in the success or failure of 1:1 computing. It is critically important to appreciate the pivotal role that classroom teachers play in the success of 1:1 computing. Looking across all of the available data, it is clear that teachers nearly always control how and when students access and use technology during the school day. In addition, teachers must make massive investments in time and effort to adapt their teaching materials and practices to make the 1:1 environment effective and relevant. With the adoption of the BWLI program, teachers were asked to change their existing practices and integrate technology across all aspects of their professional lives. As such, these results suggest that the burden of change is often greater for teachers than for any other participants in a 1:1 initiative.

In each of the 1:1 settings, there remained a small number of teachers who were reluctant to change their "tried and true" pre-1:1 teaching practices. In a few of these instances, school principals inferred that the BWLI program may have even led a few veteran teachers to decide to retire a little earlier than they may have originally scheduled. However, the potential changes in pedagogical approach and resources afforded by 1:1 computing also served to attract and excite both existing and incoming teachers. In nearly every pilot middle school, principals expressed pleasure at the excitement of incoming teacher applicants, many of whom commented specifically in their applications and job interviews that they were especially attracted to the school for its 1:1 program. Although the emphasis in the current study was not to determine how and why the majority of teachers exhibited enthusiasm for 1:1 computing while others were decidedly less inclined, further elucidation of the results are valuable.

Despite widespread increases in teacher and student technology use across the three years of the formal program implementation in the five participating 1:1 schools, there was no single subject area or grade level where technology uses were found to be universally more widespread or universally unused. In other words, no single subject area received universal high or low use across more than a couple of schools. Similarly, although pilot students generally reported using computers to "find information on the Internet", "take notes in class" and "access a teacher's website" as among the most frequently occurring student uses in each setting, notable differences were also observed across the student computer uses in each of the individual pilot settings. Furthermore, throughout a school day, a student during the second or third year of the program could easily go through the day without ever using their laptop if none of their teachers had a "laptop lesson" prepared. Similarly, a student in different classes with different teachers could use their laptop throughout the day within the same grade level and school setting. Taken collectively, we can conclude that it was factors *within* each school setting which played a larger role in the adoption and use of technology than factors related to trends across subject areas or grade level. Survey data, as well as the additional qualitative data collected in these 1:1 schools, suggest that teachers' adoption of technology is related to a number of factors. These factors include teachers' beliefs and attitudes about pedagogy and the value of educational technology, ease of access to technology, quality and timeliness of technology support, professional development and training, as well as a school culture and leadership that values and promotes technology.

In previous research, it has been shown that teachers' pedagogical philosophy and beliefs towards educational technology can strongly shape how likely teachers will be to adopt and use technology for different purposes in school (Bebell, Russell, & O'Dwyer, 2004; Russell, Bebell, O'Dwyer, &

O'Connor, 2003; Ravitz, Wong, & Becker, 1999). In every 1:1 pilot school there was a wide range of staff with varied beliefs and experiences concerning educational technology. Again, it was suggested that a minority of teachers reported to be very hesitant in changing what they regarded as their own time-tested and effective educational practices. However, just as we have collectively witnessed in popular culture over the past decade, the overwhelming sentiment towards the new technology was one of general acceptance and optimism. Again, as both the classroom observations and teacher survey data show, pilot teachers were very quick to begin making use of their BWLI laptops for a number of educational aims and purposes. Even before the student deployment had officially begun, the vast majority of pilot teachers had already incorporated a wide variety of regularly occurring new technology applications. The most frequent of these uses included preparing and researching lesson plans using the Internet and other computer-based resources. Teachers widely commented that they had suddenly and infinitely expanded their available curricular materials and teaching resources. Use of the new computers for communication also grew rapidly as teachers used email to communicate with leadership and other staff as well as with students and parents. Many teachers also developed web sites for their classes, which typically served as repositories for student resources and digital curricular materials as well as organization and project based managerial sources for their classes. Teachers shared stories of assisting their students with homework via text/instant messaging.

Across most applications of technology, it was those teachers who adopted new uses for computers (particularly for direct instructional use), who also reported the most comfort and ability to use technology. In other words, across pilot settings, it was those teachers who adopted and frequently used technology for various aspects of their teaching who more highly rated the value of technology than those teachers who used technology with less frequency. Thus, if teachers do not value technology first and therefore make fewer attempts to use it, they may never realize the educational benefits that those teachers who more frequently use technology consistently cite. These cyclical results perhaps suggest that increased use of technology by teachers led to teachers' increased valuations for technology while teachers who valued technology less, used it less, and therefore observed fewer positive outcomes. Hence, the importance of professional development and support, both of which teachers reported were most beneficial when the focus was shared between technology mechanics (i.e. learning new applications, software) and the integration of meaningful technology into the curriculum.

There is also a fairly common assumption in education that new generations of teachers will promote and master the use of educational technology in the classroom given their personal exposure to technology while growing up. Research from non-1:1 settings as well as observations across the pilot settings, suggests this assumption is only partially true. It was observed that in general the younger generation of teachers most quickly adopted and applied technology resources to support their teaching with widespread use of computers to research lesson plans and communicate with professional peers. However, teachers' age was largely unrelated to use of technology for instructional purposes and with students in class, and we found that newly hired teachers often took a few years of acclimation before they were regularly using technology as a dominant instructional tool and with their students.

Teachers' access to technology resources also varied across the pilot settings in ways that likely impacted the frequency of teacher and student use as well as the program outcomes. Although all students and teachers were provided laptop computers and wireless learning environments, access to peripheral and supporting resources varied greatly across the three years of the project deployment and across the five school settings. The results suggest that in some cases, 1:1 student and teacher laptops were not always entirely adequate or sufficient for meeting the hardware and software needs of each teacher. For example, despite 1:1 student laptops, teachers noted obstacles when LCD projectors were not easily available to them. Another example was a lack of printers available in some pilot schools. The point of such examples is that even when student and teacher computers were universally provided, there were numerous examples when technology resources and equity issues still became obstacles in successfully transforming teaching and learning practices. Clearly, to those designing and managing 1:1 initiatives there are many considerations beyond teacher and student computers, all of which potentially impact the efficacy and outcomes of the program.

As the BWLI pilot program was implemented in five varied middle school environments, it is possible to consider the impacts of these differences on how the program was implemented as well as what outcomes were generated. Although the purpose of this paper does not allow for a definitive exploration of what factors were critical to the success of 1:1 computing, a number of naturally occurring differences across participating schools deserve greater scrutiny and attention. For example, school and district leadership led to differences in how the program was managed which seemed to then impact use and outcomes. For example, in one school, after the second year of implementation other priorities and obligations left the school without any clear leadership concerning the management and oversight of the pilot program. From a research perspective, it was noted that this was also the same school where teacher and student technology use was regularly lowest in the student and teacher surveys, underscoring the potential link between school-level leadership and 1:1 program outcomes.

As is the case with nearly all research of interesting and evolving educational initiatives, perhaps as many questions are raised by the current examination as are answered. In describing his early enchantment and rich educational experiences resulting from his discovery of gears and transmissions at age two, educational theorist and mathematician Seymour Papert warns of the challenge (or impossibility) of addressing and quantifying the potential educational effects and impacts of providing children with rich learning environments and tools. In the Preface to *Mindstorms* Papert writes: *"If any 'scientific' educational psychologist had tried to "measure" the effects of this encounter, he would probably have failed. It had profound consequences but, I conjecture, only many years later. A 'pre- and post-' test at age two would have missed them"* (Papert, 1993, p. xx). In many ways, the impacts of the rich learning environments afforded by the 1:1 pilot program are equally hard to consider and quantify, especially such a short time after the program was started. In both teacher surveys and principal interviews, the majority of faculty and leadership stated that the impacts of 1:1 computing may take many years to be realized.

It is especially important to consider that the current results are not without their own limitations. Given the exemplary participation rates for each year of data collection, the emphasis of the current investigation relies upon quantitative data collection techniques (student surveys, teacher surveys, student achievement analyses) whereby it is possible to determine how representative or widespread any finding or result may be across all participants. The site visit data summarized in the current paper (classroom observations, teacher interviews and principal/school leadership interviews) does not provide much indication as to how widespread or universal the observations or the sentiments expressed in the interviews may actually be across all the BWLI classrooms and schools. Thus, to maximize the validity of the evaluation results, multiple data sources were employed to address each of the targeted learning outcomes.

The response rates from the BWLI teacher and student surveys were generally excellent allowing us to place more confidence in the assertion that the data presented herein adequately and properly represents the use and beliefs of the BWLI students and teaching staff. However, when considering the "final" Year 3 results, it is also important to remember that responding students in June 2008 had been in a 1:1 setting for only two years or less. Similarly, it is important to consider that for the majority of the teacher respondents, the final June 2008 teacher survey was completed after less than two years of participation in 1:1 student computing. Only seventh grade teachers had more than two years of 1:1 experience when the final rounds of the survey were collected. As such, it is important to remember that many of the teacher survey respondents may be drawing only on their initial experiences when addressing these issues. However, given that BWLI teachers are in one of the best positions to observe the effects of the program, they are equally one of the best sources of information for investigating its impact and current data provides an excellent examination of teachers' beliefs and experiences in newly developed 1:1 settings.

As the opening quote in the *Introduction* by Papert warns, the long term impacts and effects of providing students with new learning tools and environments can be extremely difficult or impossible to quantify. Given the thirty-six month study timeline, only the immediate and short-term outcomes of the program can be addressed to suggest the possibility of the long-term impacts of providing teachers and students with technology resources. These long-term effects, however, cannot be understood without the quantification and documentation of technology use in the short term. Again, before any of the proposed benefits of an educational technology can be explored, the research team must be able to document if technology use is actually occurring. While there is a strong desire to examine the impact of technology on student achievement, research suggests that the impacts on learning must first be placed in the context of teacher and student technology use (Bebell, Russell, & O'Dwyer, 2004). However, through the current pre/post comparison study of teaching and learning practices across BWLI schools, it is possible to begin to frame the potential long term impacts resulting for teachers and students from increased exposure to computer-based technologies.

Finally, one of the great challenges facing educators and policy makers with educational technology is the rapid pace at which technology resources are constantly evolving. For example, the cutting edge Apple iBooks provided to all students and teachers at the beginning of the BWLI program, were showing the limitations of their age and amount of use by the second year of the program. Particularly for those teachers who became heavily invested in using their computer, the limitations of memory, hardware, and software were realized. In short, technology resources often have a particularly short shelf life compared to traditional educational resources. If the pilot program was replicated at the time of this publication (Fall 2009), project and school leadership would likely be investigating technologies that were largely unheard of four years ago, such as interactive white boards, and web-based productivity software and resources such as google docs. Further, national rhetoric since Barack Obama's election in November 2008 suggests a growing degree of federal interest and support for investments in educational technology resources while programs such as the One Laptop Per Child (OLPC) Foundation and Intel's Classmate

PC have created considerable international attention for low energy, low cost student laptops as an educational and economic reform in some of the world's emerging economies. Finally, we would be remiss to not mention that the increasing majority of students themselves in recent years have quickly adopted and widely employ technology across all aspects of their personal lives, from multi function cell phones to the emerging ways students are using Internet resources for communication, recreation, and entertainment. This increasing gap between students and educators has even led some to adopt the term "digital native" to describe just how differently today's students relate, think, and apply technology to their world than those of prior generations who were not raised in a computer age (Prenksy, 2006).

For most participants and close observers of the initiative, the general observation has been that the program has had many far reaching and positive educational impacts, but not all of these impacts were realized universally across all participants and schools. As such, the results of this program do not address the actual potential of 1:1 computing as much as they speak to one specific implementation of a 1:1 program in five varied middle school settings. In other words, the study results should not be viewed as a definitive assessment of 1:1 computing and educational technology, but an example of the potential of 1:1 computing as implemented through a program that brought 1:1 resources into five middle school settings from 2005 to 2008.

In conclusion, the current study found many positive educational impacts resulting from participation in 1:1 computing program. From these results, it is easy to conclude that the potential of 1:1 student and teacher computing holds major promises for transforming teaching and learning, although there are many clear and notable obstacles. It is also challenging to predict how technology itself will change in the future and how the educational needs of increasingly tech-savvy students will be met by future educators.

Endnotes

1. Zucker and Light (2009) provide a recent summary of costs and expenses associated with 1:1 laptop programs.
2. St Joseph represented a particularly unusual study site. After the beginning of the BWLI, the parochial schools of Pittsfield restructured their original participating school (St. Mark) so that all their 8th graders were moved to St. Joseph, an established 9–12 school. Given this late restructuring, the administration and faculty at St. Joseph were substantially less involved in the development and implementation of the 1:1 program than any of other original 1:1 schools.

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RESEARCH ARTICLE

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An analysis of motivation strategies used within the small-group Accelerating Mathematics Performance through Practice Strategies (AMPPS-SG) program

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Abstract

More than half of students in the USA perform below a proficient level in math. Although evidence suggests that intervention in elementary school is critical to supporting struggling learners, and there are several research-supported instructional practices to support students with math difficulties, the existing research is limited with regard to the impact of motivational strategies designed to improve students' math skills. This study examined the effectiveness of specific motivational strategies used in the small-group Accelerating Mathematics Performance through Practice Strategies (AMPPS-SG) intervention program. A multiple baseline design was used with three instructional groups of second grade students to compare the relative effectiveness of three different conditions on students' math computation skills. Condition 1 included all of the AMPPS-SG instructional components. Condition 2 included all instructional procedures as well as goal-setting, performance feedback, and reinforcement for performance. Condition 3 included all components used in Condition 2, as well as a group-based reward contingency. Results showed that students' performance during Condition 3 was significantly better than performance during Conditions 1 and 2.

KEYWORDS
AMPPS, computation, fluency, intervention, mathematics, motivation, tier 2

1 | INTRODUCTION

Mathematics achievement has been correlated with several important life opportunities and experiences. Often math is described as an important correlate of employment within many fast-growing jobs (Jones, 2014; Stone, Alfeld, & Pearson, 2008), but it is also positively associated with social and psychological well-being. For example, Bynner and Parsons (2006) found that poor numeracy is associated with lower self-esteem, higher level of depression, and more trouble with authorities. Despite its importance, many students experience challenges and difficulties in learning math. For example, only 40% of fourth graders in the U.S. performed at or above proficient levels on the National Assessment of Educational Progress (National Center for Education Statistics [NCES], 2017). Research has illustrated that difficulties with math begin during primary school, and either stay stable or become worse throughout schooling (Kohli, Sullivan, Sadeh, & Zopluoglu, 2015). Because students' number concept in their second grade has a significant effect on their third grade calculation performance ($R^2 = .23$; $p < .001$; Fuchs, Geary, Fuchs, Compton, & Hamlett, 2003), the second year of primary school is arguably a critical period for students to strengthen their foundational math skills.

2 | EFFECTIVE MATH INTERVENTION COMPONENTS AND PRACTICES

Meta-analyses and comprehensive literature reviews offer substantial guidance about effective components of math instruction and intervention for elementary-aged students (e.g., Codding, Burns, & Lukito, 2011; Codding, Volpe, & Poncy, 2017; Swanson, 2009). The following sections summarize this research-base:

2.1 | Practice, modeling, and combining intervention strategies

Of the interventions targeting students' math computation (e.g., addition or subtraction), instructional components such as drill and practice, modeling, speeded practice (speed-based intervention and explicit timing), using flash cards, and combining two or more intervention components are all reported to have large effect sizes for students with low math achievement or learning difficulties. For example, Codding, Hilt-Panahon, Panahon, and Benson (2009) conducted a systematic review on math computation interventions and reviewed 37 studies from 1980 to 2007, representing 914 K-12 students with mathematic computation difficulties. Using flash cards with computation items yielded large effect sizes ($d = 1.12–2.58$). Conversely, the explicit timing intervention requiring students to complete as many problems as possible in 1 min had mixed results, yielding effect sizes ranging from small to large ($d = 0.20–1.14$). The explicit timing strategy produced large effect sizes when the goal was to improve computation rate, but small effect sizes when used for computation accuracy.

In another meta-analysis, Codding, Burns et al. (2011) reviewed 17 single-case design studies on mathematics basic-fact fluency interventions with 55 students between grades 1 and 6, all of whom experienced math learning difficulties. Intervention components were categorized into four types of instructions: drill, practice with modeling, practice without modeling, and self-management. Drill and practice are fluency-building approaches summarized by

Fuchs et al. (2008) as one of the seven principles of effective intervention for students with mathematics disabilities. The difference between drill and practice is that drill is the rehearsal of isolated items recently learned (e.g., flash cards), whereas practice allows learners to use recently learned skills and established skills together (Haring & Eaton, 1978). In the Codding, Burns et al. (2011) study, modeling was generally considered as a process where a teacher demonstrates step-by-step how to solve a math problem with one or more students. One key finding of their meta-analysis showed that drill ($\Phi = 0.92$) and practice with modeling ($\Phi = 0.71$) were highly beneficial for students, yielding large effect sizes. Integrating three or more intervention components was also well-supported ($\Phi = 0.68$; moderate effect size). In another meta-analysis, Methe, Kilgus, Neiman, and Riley-Tillman (2012) also found a moderate effect size for combining intervention components (Improvement rate difference; IRD = 0.65) and reported a large effect size in speed-based interventions, such as a one-minute calculation “sprint” or cumulative review flash-card drill (IRD = 0.97).

2.2 | Explicit instruction and strategy instruction

Other reports (Dennis et al., 2016; National Math Advisory Panel [NMAP], 2008; Swanson, 2009) have reviewed interventions targeting general math competence in areas such as computation, operations, word problems, fractions, and algebra. Across these reviews, explicit instruction and strategy instruction were found to be instrumental in students’ math learning, particularly when combined (Swanson, 2009). Explicit instruction generally involves teachers using step-by-step modeling of how to complete specific math problems, as well as teachers providing guided practice opportunities, cumulative review, and corrective feedback on the set of math problems (Codding et al., 2017; Gersten, Chard et al., 2009; NMAP, 2008). Strategy instruction focuses on teachers modeling general problem-solving heuristic strategies, as well as reminding students to apply and self-evaluate the use of those strategies (Codding et al., 2017; Swanson, 2009).

2.3 | Additional strategies

One additional review study is pertinent to the present study because they found supportive evidence for other math intervention strategies not previously described. Specifically, Gersten, Chard et al. (2009) synthesized math intervention studies from 1971 to 2007 for school-aged students with a math learning disability and found support for asking students to verbalize their reasoning aloud when solving math problems ($g = 1.04$; large effect size) as well as using visual representations during math problem-solving ($g = 0.46$; medium effect size), an approach that helps students link the relationship between quantitative information in math problems with symbolic mathematical operations (e.g., ten frames, number lines, percent bars).

Finally, we highlight that the previously summarized effects of math interventions are also presented as recommendations within the Institute of Educational Science Practice Guide for K-8 math interventions (Gersten, Beckmann et al., 2009). For example, the Practice Guide recommends that “instruction during the intervention should be explicit and systematic [and should] include providing models of proficient problem solving, verbalization of thought processes, guided practice, corrective feedback, and frequent cumulative review” (p. 6).

3 | MOTIVATIONAL COMPONENTS WITH UNKNOWN OR INCONSISTENT EFFECTS

Although the instructional approaches and components discussed previously all have relatively compelling evidence of effectiveness when used with students with a math disability and/or those who struggle to learn math foundational skills, there are still several unanswered questions within the math intervention research. Most notably, the research related to motivation and its impact on math performance is still unclear. The National Mathematics Advisory Panel (2008) indicated, for example, that students who believe that effort is essential when learning math achieved higher math performance than those who believe math is an innate ability, and that students' beliefs can be changed through motivational strategies (also see Dweck, 2008). Reports also suggest that students with a math disability usually suffer from low motivation and underdeveloped self-regulation skills, which might compromise their math performance (Montague, 2007; NMAP, 2008; Swanson & Jerman, 2007). Motivational strategies are recommended to help students understand the importance of effort in learning math and improve their skills. Evidence supporting motivational strategies during math intervention is currently considered low (Gersten, Beckmann et al., 2009), but there are some potentially promising strategies.

3.1 | Performance feedback, goal-setting, and reinforcement

Researchers have studied several different strategies for improving students' motivation. Promising strategies include (a) performance feedback with goal-setting, (b) reinforcement contingent on performance, and (c) group reinforcement for effort and engagement. Based on previous work (e.g., Codding, Chan-Iannetta, Palmer, & Lukito, 2009; Codding, Chan-Iannetta, George, Ferreira, & Volpe, 2011), performance feedback with goal-setting is mainly composed of the following steps: (a) having the student mark his or her responses with a given answer key after a brief math assessment, (b) calculating the student's score and recording it on a graph, (c) showing the student (using the graph) how the score improved (when applicable), and (d) encouraging the student to beat his or her previous score during the next assessment. With a sample of third grade students, Fuchs et al. (2014) reported a positive effect for a math intervention involving a self-regulated learning strategy that incorporated goal setting and self-evaluation. However, calling into question the effectiveness of goal-setting during math interventions, Gersten, Chard et al. (2009) found a statistically significant but low effect size for using feedback and graphs of students' performance ($g = 0.23$), and a low and statistically insignificant effect size ($g = 0.17$) for using goal setting with progress assessment toward the goal.

Contingent reinforcement often refers to the use of verbal praise and/or small, tangible rewards contingent upon students' academic performance. Swanson's (2009) meta-analysis only found that 4 of 28 studies evaluated reinforcement as a math intervention component using a group design for students with a math disability, and only one study yielded a high effect size in improving students' mathematic performance. In a review, Codding, Hilt-Panahon, et al. (2009) found that goal-setting yielded a large range of effect sizes on math fluency with K-12 students with math difficulties ($d = 0.19–1.2$), with higher effect sizes reported from goal-setting that was combined with contingent reward, and lower effect sizes with noncontingent reward conditions. These findings may suggest that contingent reinforcement combined with performance feedback and goal setting may produce better outcomes.

Reinforcement based on effort and engagement also has preliminary evidence as an effective component of a math intervention. Because on-task behavior is generally incompatible with problem behavior (Ducharme & Shecter, 2011), and students' attention in class has been reported to be the most robust predictor of their math performance in first grade (Fuchs et al., 2005), student on-task behavior seems to positively affect academic performance. Providing students with feedback about effort may also lead to higher self-efficacy and better math subtraction skills in students with learning disabilities (Schunk & Cox, 1986). Some studies have examined the effects of feedback for effort when used in an interdependent group contingency (i.e., a small reward is provided to all participants in the group when the collective on-task behavior meets a pre-specified criterion). A meta-analysis on group contingency procedures to improve targeted behavior for school-aged students found a large effect size of 2.88 for interdependent group contingencies (Little, Akin-Little, & O'Neill, 2015). In the vast majority of studies, group contingencies are applied to whole-class instruction and no known studies have evaluated group contingencies with small instructional groups of 3–6 primary grade students.

4 | RESEARCH QUESTIONS AND PURPOSE OF THE PRESENT STUDY

Existing research suggests that instructional components, such as explicit instruction, strategy instruction, opportunities for practice, and visualization, can meaningfully improve students' math skills. Some experts suggest that motivational strategies should be integrated within math instruction for struggling learners, but additional research is needed to examine specific strategies designed to enhance students' motivation during math instruction (e.g., goal-setting, reinforcement, and group contingencies). From the existing research base and gaps within it, the central purpose of this study was to examine the relative effectiveness of three different intervention conditions. Condition 1 included several evidence-based instructional practices designed to improve computation skills for elementary-aged students. Condition 2 included the same evidence-based instructional practices from Condition 1, in addition to (a) performance feedback with goal setting and (b) reinforcement for improved math performance. Condition 3 included the same instruction and motivational components used in Condition 2, as well as a group-based contingency for effort. Our two primary research questions were:

1. Is Condition 2 more or less effective than Condition 1 and Condition 3?
2. Is Condition 3 more or less effective than Condition 1 and Condition 2?

Although existing research is relatively limited in its analysis of motivational strategies to improve students' math performance, we hypothesized that the combination of evidence-based instruction, performance feedback with goal setting, reinforcement for improved performance, and group-based contingency for effort (i.e., Condition 3) would be more effective than Conditions 1 and 2. We also hypothesized that instruction plus at least some motivational strategies (i.e., Condition 2) would be more effective than instruction alone (i.e., Condition 1).

As an exploratory research question, we also asked: did participants show meaningful improvements in math computation fluency over the duration of the project? This was a supplemental research question because our choice of experimental design was best fit to address the primary two research questions.

5 | METHOD

5.1 | Participants and setting

Participants included second grade students who were selected using the following procedures. First, as part of the standard assessment procedures in the participating school (an urban elementary school located in the southeast U.S.), all students from the three different second grade classrooms ($N = 58$) received winter benchmark assessments using the AIMSweb Mathematics-Concepts and Application (Person Education, 2012; M-CAP) and the AIMSweb Mathematics-Computation (Pearson Education, 2012; M-COMP) measures. All students who scored below the 50th percentile on the M-CAP and M-COMP ($n = 19$) were then further assessed with Mathematics Computation Curriculum-Based Measures (Shinn, 2004; M-CBM) to determine each student's instructional level (Shapiro, 2011) on three different two-by-one digit (e.g., $12 + 5$, $11 - 3$, $10 + 4$) M-CBM probes: addition, subtraction, and mixed addition-subtraction. From this assessment, any student who scored at a mastery or instructional level on all three probes ($n = 1$) or at a mastery level on the addition probe ($n = 4$) were excluded from the study because they had computation skills that were strong enough not to need the type of intervention support offered in this study.

Of the 14 students who remained eligible for participation, we sought to develop three instructional groups of three students each. Students who performed similarly on each of the three M-CBM probes were considered to have relatively homogenous skill levels and were randomly assigned to an instructional group of students with similar math abilities. Of these nine participants, all performed at the instructional level for addition. For subtraction, seven performed at a frustrational level and two performed at an instructional level. For the mixed probe, five performed at a frustrational level and four performed at an instructional level. Unfortunately, one student moved within a couple weeks of project commencement, leaving eight participants in total. Group and student participants are identified with numbers. Specifically, Group 1 includes students 1, 2, and 3; Group 2 had students 4, 5, and 6; and Group 3 had students 7 and 8.

Of these eight participants, none were receiving special education or English as a Second Language services; six were female, two were Black, three were Latino, and three were White. Due to school district policies, we could not obtain information about an individual student's eligibility for free or reduced-price lunch, but at the participating school, 35% of the students were receiving free or reduced-price lunch. The participating school was selected based on convenience and close geographical proximity to the interventionists involved with the study.

Interventionists included three undergraduate students and two graduate students, each of whom were trained to implement the instructional and motivational procedures described in Sections 5.3 and 5.4. Specifically, each interventionist was first shown how to implement the full implementation protocol from an interventionist who had previously implemented the protocol with perfect integrity for several months. Interventionists then practiced implementation and received feedback from the experienced interventionist, and then each interventionist implemented the full protocol at least two consecutive times to ensure 100% integrity on both the core implementation procedures and the tips/reminders checklist (described later). All interventionists were required to meet this criterion before being able to implement the protocol with a student participant, and implementation integrity with student participants was continuously monitored (described later). Intervention sessions were conducted in a room within the participating school that was free from noise and distractions.

5.2 | Measures

5.2.1 | Mathematics-concepts and application

Provided by AIMSWeb, a web-based assessment system supporting universal screening and progress monitoring for grades K-12, mathematics-concepts and application (M-CAP) is an 8-min test assessing students' general mathematic problem-solving skills, including domains of number sense, operation, measurement, and patterns and relationship. When scoring M-CAP, a score of 1, 2, or 3 is given to students for correct responses, and a score of 0 for incorrect responses. The criterion validity ranged from 0.63 to 0.67 when correlated with the third grade North Carolina End of Grade Test, and the alternate form reliability is 0.86 for second grade (Pearson Education, 2012).

5.2.2 | Mathematics-computation

Mathematics-computation (M-COMP) from AIMSWeb is consistent with M-CAP, in terms of test format, test time, and scoring rules. As for the content, the M-COMP test is composed of 28 items of addition and subtraction problems to examine whole number operation skills. Alternate form reliability of the M-COMP was 0.82 for second grade (Pearson Education, 2012). Using the Group Mathematics Assessment and Diagnostic Evaluation, the criterion validity coefficient of M-COMP ranged from 0.73 to 0.84 (Pearson Education, 2012).

5.2.3 | Mathematics computation curriculum-based measurement

Mathematics computation curriculum-based measurement (M-CBM; Shinn, 2004) is a timed test with 84 computation problems (items), with numerals per item ranging from 0 to 20. Students are asked to answer as many problems as they can within 2 min. Each digit correct, rather than each completely correct answer, is calculated for M-CBM. For example, the item 3 + 8 allows for two digits correct if answered correctly as 11 (one digit in the tens' place and one digit in the ones' place). Digits correct per minute (DCPM) is then calculated by dividing a student's number of digits correct by two. Estimates of M-CBM inter-scorer agreement is 0.83 and alternate form reliability is 0.91 (Shinn, 2004). Validity coefficients range from 0.40 to 0.80 across types of CBM for math (Christ, Scullin, Tolbize, & Jiban, 2008; Foegen, Jiban, & Deno, 2007).

As was described earlier, M-CBM benchmark probes were used for screening purposes and determining homogenous instructional groups. They were also used for pre-post assessment. Students' scores on the three M-CBM benchmark probes gathered for screening and grouping purpose constituted as pre-assessment data. Postassessment data were gathered by administering the same three benchmark probes at the end of the study (i.e., the day after the last intervention session). In addition, M-CBM progress monitoring probes were used in the study to compare students' performance across the different experimental conditions. During each intervention phase, students were administered an M-CBM progress monitoring probe at the end of the session every Tuesday and Thursday. Each group's median score per assessment session served as the primary dependent variable within our multiple baseline experimental design.

5.3 | Instructional procedures

Each instructional session lasted approximately 25–30 min and instructional sessions were implemented two to three times per week for 14 weeks. All participants received instructional procedures that are included as part of the Accelerating Mathematics Performance through Practice Strategies math intervention program (Codding & Begeny, 2019) for small groups (AMPPS-SG). The overall goal of AMPPS-SG is to improve whole number knowledge, including computation and word problem solving, for elementary-aged students with low achievement in mathematics. AMPPS-SG was designed as a Tier-II intervention to be implemented in a small group of two to four students. The instructional curriculum used in AMPPS-SG is divided into five units, each containing three lessons, beginning with simple addition, followed by basic subtraction, a review unit of basic facts (addition and subtraction), an introduction to fact families, and lastly a unit containing complex addition and subtraction problems through 20. One lesson is implemented per instructional session. AMPPS-SG instructional components include the following evidence-based strategies: modeling, corrective feedback, guided practice with story problems, explicit timing, and flash card drills. Implementation of these instructional components also allowed students to use visual representations of number relationships, such as using ten frames, number lines, and drawings (Gersten, Chard et al., 2009). Summarized below are the primary instructional procedures and materials used in AMPPS-SG.

An AMPPS-SG intervention session starts with student completion of a 1-min computation worksheet consisting of problems relevant to the lesson for that day that we henceforth refer to as *Sprint #1*. Students' performance on Sprint #1 is used to determine whether students move to the next lesson in the AMPPS-SG curriculum using criteria described by Burns, VanDerHeyden, and Jiban (2006). If the group of students' median score is 17 DCPM or higher and 2 digits incorrect per minute (DIPM) or less, students are administered a new Sprint #1 that corresponds with the new lesson. If these criteria are not achieved, the group proceeds with the initial lesson.

After Sprint #1, practice strategies within the AMPPS lesson includes the following activities, in order: (a) guided practice on specific math problems (determined according to the unit and lesson for the day) facilitated through verbal rehearsal and visual representation; (b) word problem-solving while also using a ten frame (i.e., the interventionist models problem-solving of a word problem by thinking out loud and visualizing on a ten frame, then students are instructed to use this same strategy while solving a word problem on their own); (c) three-minute cumulative review (i.e., students responded orally to flash card drill in a round robin format where students in the group are randomly and individually selected to respond); (d) completion of Sprint #2 (i.e., students complete a math computation sheet of the same problems completed in Sprint 1 but arranged in a different order on the page); and (e) each student scores his or her own Sprint #2 paper as the interventionist reads the answers and monitors students' scoring.

5.4 | Experimental design and conditions

A multiple baseline experimental design across three instructional groups was used to evaluate the effectiveness of each experimental condition and allowed for an evaluation of RQ1 and RQ2. Although single-case experimental designs (SCDs), such as multiple baseline designs, often involve four or fewer total participants (Begeny, Levy, & Field, 2006), SCDs are widely used and deemed by national experts and agencies (e.g., the U.S. Department of Education's *What Works Clearinghouse*) to offer rigorous and appropriate methods of experimentation and causal inference (e.g., Horner et al., 2005; Kazdin, 2011; Kratochwill et al., 2013; Normand, 2016). In fact, in a review of experimental studies published between 2010 and 2014 in six school psychology journals, Villarreal, Castro, Umana, and Sullivan (2017) found that SCD studies were the most commonly used type of experimental design, appearing in 40.6% of the published intervention studies. Each experimental condition in our study is described in turn.

Condition 1. In Condition 1, student participants received each of the AMPPS-SG instructional components described previously.

Condition 2. In this condition, students received each of the AMPPS-SG instructional procedures used during Condition 1 in addition to (a) performance feedback with goal setting and (b) reinforcement for improved math performance. Performance feedback with goal setting involved the interventionist graphing each instructional group's median score on the Sprints, and encouraging all students to reach the group goal (i.e., at least 17 DCPM and 2 or less DIPM) in Sprint#1. During each instructional lesson, each student was also encouraged to obtain more DCPM during Sprint #2 compared to his or her Sprint#1 score. Reinforcement for improved math performance involved a Star Chart and Prize Box, which were used consistently with past research (e.g., Begeny, 2011; Mitchell & Begeny, 2014). More specifically, each group would earn one star for meeting the group goal in Sprint#1 and another star for increasing the group median score from Sprint#1 to Sprint#2. When the group of students earned 15 total stars (i.e., completed one row on the Star Chart), each student could select a small, age-appropriate prize from the prize box (e.g., a pencil, sticker, small toy).

Condition 3. In Condition 3, all procedures from Condition 2 were used, but a group contingency, called the *You/Me Game*, was applied. With this procedure, students could earn points for their on-task behaviors (e.g., following the interventionist's instructions during the lesson), while the interventionist could earn points if students did not show on-task behaviors. At the end of the lesson, the student group could earn an additional star for winning the game and another star for winning by more than 5 points.

5.5 | Procedural integrity and interscorer agreement

Procedural integrity was evaluated by a second member of the research team who was also trained to use all the previously described procedures. The observer examined the interventionist's use of the core procedures involved with each condition (e.g., 13 steps for Condition 3) as well as implementation quality factors and steps referred to as *tips and reminders*. All interventionists were regularly observed and a total of 32.6% of the sessions were observed for procedural integrity. Across all observations, an average of 100% of the core procedures and 98.7% of the tips and reminders were implemented with fidelity. Also, 100% of students' progress monitoring probes were double-scored for inter-scorer agreement by having an independent member of the research team score the probes for DCPM and DIPM. Inter-scorer agreement was calculated by dividing the number of agreements on DCPM by the number of agreements plus disagreements, and then multiplying by 100. Mean agreement for progress monitoring probes was 98% (*range* = 82%-100%).

5.6 | Data analysis strategy

To determine if students' math computation performance improved as a function of condition, DCPM median group scores across the three conditions were graphed by small group and analyzed visually. Despite many effect size methods available for SCDs, visual analysis is still the most commonly used and recommended analytic method for these types of designs (Kazdin, 2011; Kratochwill et al., 2013). Consistent with recommendations, group median scores were examined according to level, trend, variability, immediacy of effect, overlap, and consistency of data patterns (Kratochwill et al., 2013). For visual analyses, our unit of analysis was by small group because instruction occurred at the small-group level and many researchers argue that group level analyses are most appropriate in this context to account for factors such as nonindependence and the potential for mutual influence (e.g., Hoyle, Georgesen, & Webster, 2001; Kenny, Mannetti, Pierro, Livi, & Kashy, 2002). School psychologists using SCDs to experimentally evaluate group-based interventions also use this logic and visually analyze data at the group level (e.g., Begeny & Martens, 2018; Scott et al., 2017).

Additionally, Tau effect sizes (Vannest, Parker, Gonen, & Adiguzel, 2016) were computed as a secondary analysis. Tau is the percentage of non-overlap minus overlap, and is a proportion that ranges between −1 and 1 (Solomon, Howard, & Stein, 2016). Tau was used instead of percent of nonoverlapping data because Tau (a) takes both trend and nonoverlapping data into account, (b) can identify and accommodate baseline trend if it exists (i.e., Tau-U), (c) is ideal for smaller datasets, and (d) correlates well with other nonparametric indices (Parker, Vannest, Davis, & Sauber, 2011; Vannest et al., 2016). Tau, rather than Tau-U, was calculated in this study because there were no significant baseline trends demonstrated in the data set (Parker, Vannest, & Davis, 2011). Vannest and Ninci (2015) suggest the following interpretation guidelines for Tau coefficient sizes: "[a] 0.20 improvement may be considered a small change, 0.20–0.60 a moderate change, 0.60–0.80 a large change, and above 0.80 a large to very large change" (p. 408). A web-based application developed by Vannest and colleagues was used to calculate Tau effect size coefficients between (a) Condition 1 and Condition 2, (b) Condition 2 and Condition 3, and (c) Condition 1 and Condition 3. The web-based calculation provides effect size coefficients and corresponding *p*-values that indicate if there was a statistically significant performance improvement across conditions.

As a supplemental analysis that helped to examine overall growth in students' math skills across the entire duration of the project, differences between pre and postassessment of three M-CBM benchmark probes were analyzed by comparing each student's expected growth to their actual growth. Expected weekly growth on M-CBM measures for second grade students has only been reported in two prior studies (Fuchs, Fuchs, Hamlett, Walz, & Germann, 1993; Keller-Margulis, Mercer, & Shapiro, 2014). Fuchs et al. (1993) found that 0.30 DCPM represented the weekly rate of improvement and Keller-Margulis et al. (2014) found a rate of 0.14 DCPM per week. In our study, we applied the findings from Fuchs et al. (1993) to use a more challenging criterion to evaluate potential improvement on M-CBM.

6 | RESULTS

6.1 | Visual analyses

Figure 1 provides group median DCPM for each group across three conditions. The small number of missing data points for Group 3 simply reflects student absences during those assessment sessions.

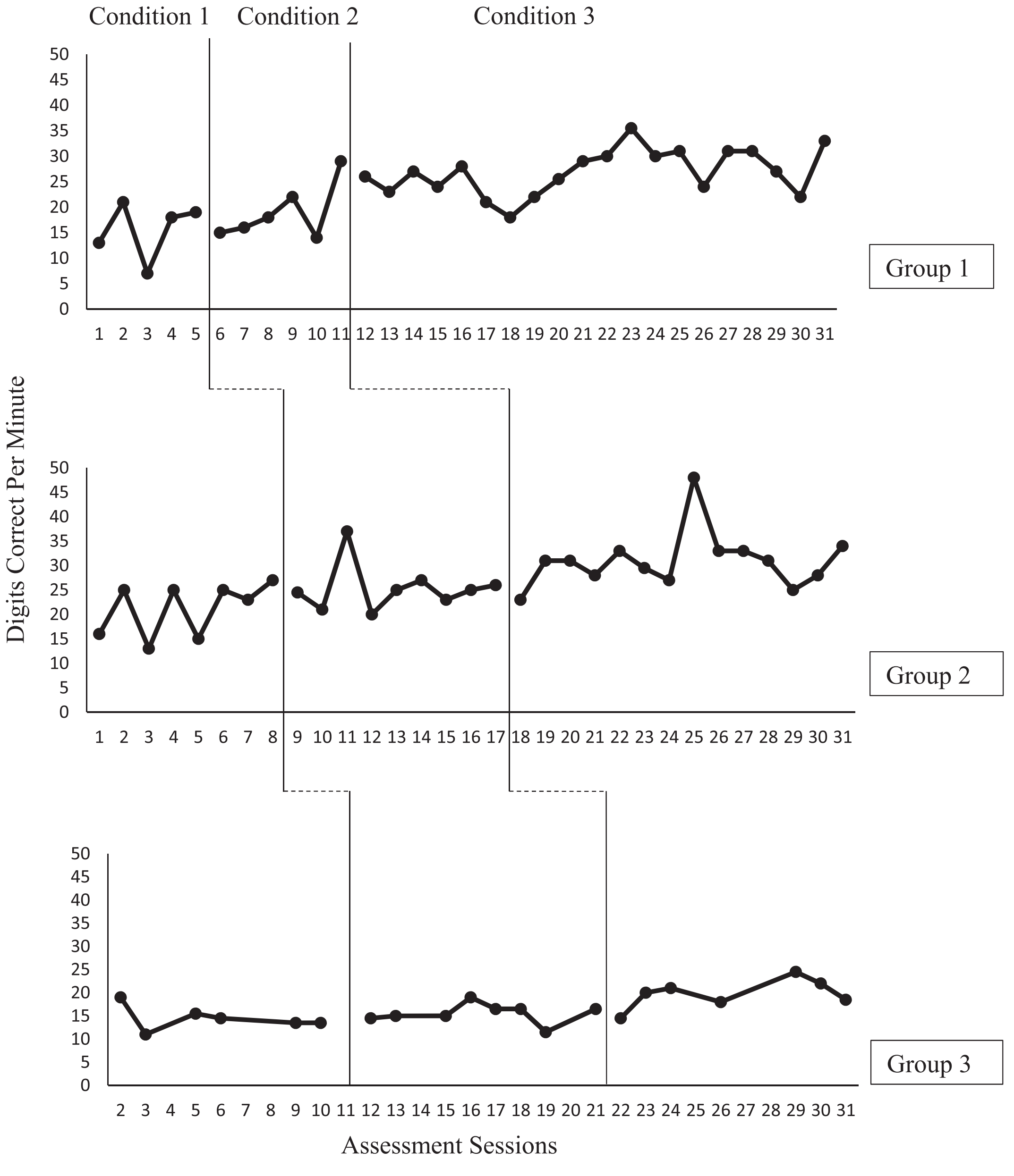

FIGURE 1 Digit correct per minute median scores per group across conditions

For group 1, the performance in Condition 1 started with slight variability but stabilized at the last two assessment sessions with a group median near 20 DCPM. During Condition 2, the median level of performance was similar to Condition 1, with a sharp increase during the last data point in the phase. Condition 3 demonstrates a generally higher level of DCPM with a slightly increasing trend.

For group 2, students' median DCPM during Condition 1 were initially variable, but stabilized during the last three assessment sessions. During Condition 2, performance was generally stable and at a level similar to Condition 1. At the beginning of Condition 3, there was a relatively immediate increase, and then a slightly increasing trend over time with some variability.

TABLE 1 Tau analyses of group median comparison between conditions

Group	Condition 1 vs. Condition 2	Condition 2 vs. Condition 3	Condition 1 vs. Condition 3
1	.23	.73[a]	.94[a]
2	.31	.65[a]	.87[a]
3	.38	.70[b]	.79[b]
Average	.31	.70[a]	.87[a]

[a] $p < .01$, with Condition 3 representing significantly higher digits correct per minute.
[b] $p < .05$, with Condition 3 representing significantly higher digits correct per minute.

For group 3, performance during Condition 1 was mostly stable at around 15 DCPM and it remained relatively stable at that level during Condition 2. At the beginning of Condition 3, students' level of performance increased after the first assessment session and remained at a higher level than earlier conditions, but with some variability and an increasing trend.

Overall, visual analyses suggest that students' performance during Conditions 1 and 2 were generally similar, with Condition 2 showing only slightly better DCPM performance. In contrast, Condition 3 evidenced higher levels of performance than Conditions 1 and 2. Descriptive data also reveal this pattern. For example, across all students, the average DCPM for Conditions 1, 2, and 3 were 17.6, 20.3, and 27.1, respectively.

6.2 | Tau analyses

Table 1 represents the tau effect size comparisons across each condition: (a) Condition 1 compared to Condition 2, (b) Condition 2 compared to Condition 3, (c) Condition 1 compared to Condition 3. Both group effect size and the weighted average effect size across the three groups are provided in the table. Comparing Condition 1 and 2, tau coefficients indicated a moderate improvement in all three groups when performance feedback with goal setting and reinforcement for performance were added to AMPPS-SG instructional components (range = 0.23–0.38). However, the effect sizes were not statistically significant. When comparing Conditions 2 and 3, tau effect sizes were large and statistically significant for each group and across all groups—each evidencing higher DCPM during Condition 3 and suggesting that the group contingency for effort significantly improved median scores for each group. Comparisons of Conditions 1 and 3 likewise evidenced significantly higher DCPM scores during Condition 3, with effect sizes even larger than when comparing Conditions 2 and 3.

6.3 | Pre and postassessment analyses

Table 2 provides each student's scores on the three M-CBM benchmark probes (addition, subtraction, and mixed addition-subtraction combined) in pretest and posttest, respectively. According to Fuchs et al. (1993), the weekly expected rate of improvement for first through third grade students is 0.30 DCPM. Thus, across 14 weeks of the intervention study, student participants would be expected to increase 4.2 DCPM. Table 2 shows that seven students exceeded expected performance on at least one of the three M-CBM assessments, and six of the students did so for all three assessments. Only Student 6 did not make meaningful progress on any of the three probes. Overall, the pre and postassessment analyses offer preliminary data to suggest that the large majority of students benefited from receiving the various instructional and motivational components that were integrated throughout the project.

TABLE 2 Pre and postassessment analyses on mathematics computation curriculum-based measurement benchmark probes

	Preassessment			Postassessment		
Participants	Addition	Subtraction	Mixed	Addition	Subtraction	Mixed
Student 1	24	5	7	58[a]	34[a]	46[a]
Student 2	30	6	11	40[a]	27[a]	27[a]
Student 3	20	7	10	41[a]	26[a]	35[a]
Student 4	27	18	18	46[a]	24[a]	28[a]
Student 5	30	11	24	39[a]	31[a]	30[a]
Student 6	28	24	27	24	24	22
Student 7	19	6	14	12	14[a]	18
Student 8	21	10	10	31[a]	20[a]	20[a]

Note: Mixed refers to a math assessment including both addition and subtraction problems.
[a]Improvements at posttest surpassed the expected growth of 4.2 digits correct per minute, as reported by Fuchs et al. (1993).

7 | DISCUSSION

The primary purpose of this study was to examine the relative effectiveness of specific motivational strategies found in the AMPPS-SG intervention with elementary school students, including performance feedback, goal setting, reinforcement for performance, and group-based reinforcement for effort and engagement. To date, there is a relatively little research that has examined the impact of motivational strategies to enhance students' success in math. Overall, our findings showed that although the motivational strategies of goal setting, performance feedback, and reinforcement for performance in Condition 2 did not yield significantly higher DCPM compared to Condition 1, they improved students' performance somewhat. However, during Condition 3, when group-based reinforcement for effort and engagement was added to the intervention components from Condition 2, students considerably improved on the measure of DCPM, as indicated by both visual analyses as well as large and statistically significant tau effect sizes. Our pre-post assessments also showed that, during the project, seven out of eight students demonstrated improvements beyond what two past studies (Fuchs et al., 1993; Keller-Margulis et al., 2014) described as expected growth for second graders on M-CBM measures.

The lack of statistically significant effects for the combination of performance feedback, goal setting, and reinforcement for performance (Condition 2) is not consistent with our hypothesis, but it is consistent with some prior research. For example, although motivational strategies are recommended by the NMAP (2008), some studies did not find significant effect sizes for strategies such as goal setting with an assessment of progress toward the goal (Gersten, Chard et al., 2009) or reinforcement/rewards (generally described) during math intervention (Swanson, 2009). However, after combining the Condition 2 motivational strategies with group-based reinforcement for effort, these large effects were commensurate with evidence suggesting the overall importance of motivational strategies, especially strategies to raise students' attention and effort (Fuchs et al., 2005; Schunk & Cox, 1986). Motivation strategies are particularly needed for fluency interventions because (a) fluency-building requires extensive practice, and (b) students with low motivation—such as those who previously experienced a lot of difficulty in the academic area—are likely to lose interest during instruction and thus benefit less from it (Foster, 2018; Haring & Eaton, 1978). From this, it is sensible that including motivators (e.g., to help students regulate their attention and behaviors to work hard) is considered as one of the seven principles of effective interventions for students with math disabilities (Fuchs et al., 2008).

7.1 | Limitations and future research directions

Data from this study should also be interpreted in light of the study limitations and the need for future research. For example, we unfortunately ran out of time during the school year to return student groups to Condition 1 after students received Condition 3; returning to an earlier condition would have further strengthened our experimental design. Additionally, as part of our experimental design, we examined the impact of adding different types of motivational procedures to evidence-based instruction, but we did not systematically examine every possible permutation of those motivational procedures. For instance, our data cannot speak to the impact of only using reinforcement for effort or the combination of only using reinforcement for effort plus goal-setting. It is possible that other combinations of motivation procedures will produce different effects, and it is possible that effects will differ based on student characteristics (e.g., older students, students with more severe math difficulties). Thus, future research is needed to further explore the potential impact of motivational procedures during math intervention.

The measures used in this study also serve as a possible limitation and need for future research to build upon (e.g., only math computation was assessed, and our pre–post assessment with M-CBM could not be interpreted using national norms). Additionally, the end of the students' school year unfortunately prevented an assessment of maintenance over time. Future research might also attempt to evaluate students' overall interest or motivation in math to determine whether academic gains are moderated by such interest. Finally, although this study provides some support for using AMPPS-SG in the way it was originally designed (i.e., the procedures implemented during Condition 3), future research should evaluate whether AMPPS-SG is more effective than other math interventions appropriate for second grade students.

7.2 | Implications for practice

With little existing research specifically examining the impact of motivational procedures designed to support elementary students with math difficulties, and little research to date that has examined AMPPS-SG, we do not want to over-generalize our findings. However, our data could have some practical implications for school psychologists and other educators—especially in light of the minimal amount of research in this area. For example, this study highlights for educators the importance of raising and maintaining students' motivation, especially for students with difficulties or low interest in math. Applicable strategies might include setting a goal for students before they begin their practice or task, graphing their performance and progress on a chart, providing positive feedback for their improved task performance, and (as highlighted from Condition 3 in this study) using strategies to promote on-task behavior and engagement. With small-group instruction being a common approach to targeted intervention in elementary school, it is particularly important that interventionists consider strategies that will keep all students in a group academically engaged.

In particular, because it is often difficult to provide individual feedback about effort and engagement for each student in a class (or even small group), when working with a group or the whole class, interdependent group contingencies for engagement might be feasible and effective. This approach helps teachers to manage on-task behaviors by making every student responsible for their collective engagement (Weis, Osborne, & Dean, 2015). For example, the teacher can give points to the whole group when one group members exhibits on-task behavior, or take off group points when a student is off-task.

Our study also provides evidence of the potential benefits of AMPPS-SG for second grade students with low achievement in math. This is promising because there are relatively few small-group interventions available that target early elementary-aged students' computational fluency, and compared with a one-on-one intervention, a small-group intervention is more time- and recourse-efficient. Furthermore, this study suggests that interventionists with little to no teaching experience are capable of learning and implementing the program with strong fidelity. For schools looking to maximize resources, there are clear advantages of utilizing packaged programs that can be feasibly implemented by adults with varying levels of teaching experience.

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