JOURNAL FOR COMPUTING TEACHERS

JCT

EDITED BY LUCIANNE BROWN

A publication of ISTE's Computing Teachers Network

Formerly the Journal for Computer Science Education (JCSE)

ISTE®

JOURNAL FOR COMPUTING TEACHERS
WINTER 2015

COLUMNS

ARTICLES

Editor's Remarks
Welcome to the 13th Online Edition of JCT

Lucianne Brown, Ph.D.
Governors State University

Welcome to the 12th online issue of the *Journal for Computing Teachers (JCT*), produced by ISTE's Computing Teachers Network. The network advances the practice of teaching computing and computer science in elementary, secondary, and postsecondary education to meet needs for all students as well as those wishing to study some aspect of the discipline in more depth.

In this winter 2015 issue, we offer six articles covering an array of topics of interest to teachers and other professionals invested in employing technology in their classrooms and computer professions.

The first article, by Kate Simmons and Kellie Shumack is not peer-reviewed, but offers an excellent example lesson of using QR codes in the classroom.

The five research papers, are all peer reviewed by our JCT Team. Author Christopher E. Duschik presents "Dialogue and Literacy Instruction: How Technology Can Bridge Equity and Underachievement Issues in Urban Settings". "The study incorporates a revised iteration of literature circles by using technology and a class blog."

In "Harnessing Mobile Devices for Ubiquitous Learning in New Zealand Schools," authors Stephanie Young and Kumar Laxman provide a discussion of mobile devices energizing student learning. They share a process for meeting mandatory curriculum update.

Zulfiqar Ali Khan and Raheel Siddiqi explore "Teaching Introductory Programming by Course Merger." They share a process for meeting mandatory curriculum updates.

In "Perceptions of Coding with MIT App Inventor: Pathways for their Future" by Danielle Herro, Christina McCune-Gardner and D. Matthew Boyer explains how coding sets a background for developing apps.

Finally, Ross Cohen presents an Action Research study by explaining a process that supports "How to Best Engage Middle School Students in Computer Programming and the STEM Fields

The *Journal for Computing Teachers* is indebted to its editorial review board for lending their volunteer expertise in the blind peer-review process. Please contact *JCT* if you are interested in being on the board or want more information about it. Email the editor at lbrown3@govst.edu.

I would like to thank all of the authors for sharing their professional knowledge and making the summer 2014 edition possible.

JCT invites papers and other materials for possible online publication. Email material directly to Editor Lucianne Brown (lbrown3@govst.edu). If you have any questions, want to discuss a possible submission, or have some ideas for the journal, please contact Dr. Brown directly.

JCT thanks the Computing Teachers Network for its continued sponsorship and promotion of this online journal. If you would like to become a network volunteer, please contact the president, Dr. Veronica McGowan, at vmcgowan@okcu.edu.

We hope you enjoy reading the winter 2015 issue of the *Journal for Computing Teachers*.

Graciously,

Lucianne Brown
Editor
Journal for Computing Teachers

Journal for Computing Teachers Peer Review Board

The *Journal for Computing Teachers* is indebted to its editorial review board for lending their volunteer expertise in the blind peer-review process. Please contact *JCT* if you are interested in being on the board or want more information about it. Email the editor at lbrown3@govst.edu.

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Implementing QR Codes in the K-12 Classroom

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Abstract

One of the most popular technology components today is the Quick Response (QR) code. While slow to catch on in education, QR code use has grown to a definable buzz as teachers discover its potential in the classroom. This manuscript explains what QR codes are, describes how they can be accessed and created, and ideas on how teachers can implement them into their own classroom.

Introduction

Educators are always looking for different ways to integrate technology so that all students are able to process information, learn independently, and have access to available resources. According to Hampton, Peach, and Rawlins (2011), there is a digital divide between those who have internet access and those who do not. This digital divide refers to the “gap and disconnect between the physical and online world.” Quick response (QR) codes are one example of how technology is being leveraged in the classroom to motivate and engage students in the learning process and to bridge the digital gap.

What are QR Codes?

QR codes are a machine-readable code consisting of black and white squares, typically used for storing URLs or other information for reading through a smart device. QR codes are similar to bar codes except that they can be scanned both horizontally and vertically, which makes them easier to scan and able to hold more information.

When scanned by a mobile device, the QR code can be used as a short cut to individualized digital files varying from webpage links, simple text, audio or video files, pictures, etc. QR codes were originally developed in the early 1990’s and used by the Japanese car manufacturing company, Toyota, to track the parts on the manufacturing line. QR codes are ubiquitous, showing up in magazines, billboards, receipts, food packages, and on innumerable other consumer products. Now, this free and easy tool is fast becoming part of an effective and popular learning strategy in the classroom.

How are QR Codes created?

A computer with internet access and a mobile device with both a camera and internet access are necessary to create and access QR codes. A printer is required if a printed copy of the QR is needed. Here are the steps for creating and using QR codes:

1. Download a free QR scanning app onto the mobile device, such as *Scan* or *Qrafter* for Apple products or *QR Scan Droid* for Android devices.
2. Create the QR codes using a free QR code generator, such as:
   www.qrcode.kaywa.com/
   www.qrstuff.com/
   http://www.qrcode-monkey.com/
3. Print the codes –right-click on the code and then copy and paste it into a *Microsoft Word* document if resizing is needed
4. Distribute the codes
5. Open the mobile device scanning app and position the device over the so that the code is visible with the camera

Many instructional websites and videos exist to help educators learn to use QR codes to create learning opportunities for students. After creating a QR code (Step 2), teachers can print them out for posting around the classroom or integrate the code in a worksheet as a kind of imbedded link in a text. Using mailing labels, teachers also print and adhere the code to desired items. Here are a few short videos to help you as well:

- How to Create QR Codes: http://youtu.be/bZdI2YM4938
- How to Use QR Codes: http://youtu.be/Xe1o5JDwp2k

Things to Consider

While there are many potential benefits to QR codes, there are also several things to consider. Using QR codes requires a mobile device with a functional camera, and many codes require access to the internet for the code to work. QR codes that access simple text do not require internet access but limit the usefulness of the code. Tablets and smartphones are the obvious choice for scanning codes, but mobile devices can be expensive. Many schools do not have the technology infrastructure necessary to provide Wi-Fi access for mobile devices; therefore, where Wi-Fi isn’t available, a mobile device with cellular internet access would be necessary.

Since more than three-quarters of American teens have cell phones (Lamb & Johnson, 2013), finding available mobile devices for classroom use may not be a issue. If there are not enough resources to ensure a 1:1 ratio of student to device, consider grouping students or have one or two extra devices (such as an iPod touch or iPad) available in your classroom.

While using a QR code is not difficult, the steps involved could be challenging to some students initially. Therefore, in some settings it is important to pre-teach skills before using QR codes. Younger students may have difficulty manipulating the mobile device's camera to access the code; however, from the authors' experience, children quickly overcome any issues with very little assistance. They are eager, adept, and unafraid when faced with new technologies.

QR Codes in the Classroom

In an elementary education classroom, teachers can use QR codes to label different activities (or stations) throughout the room. Students would interact with various physical objects with links to video, text, or picture content about an activity. The student could then see what they need to do complete the activity without direct teacher involvement. Below is video of students using a QR code to complete work at a handwriting station.

Handwriting Station QR Code Example

In a middle school setting, an assigned math problem could be given a QR code that links to a video explaining how the problem is solved. In this way, students could accomplish tasks at their own pace without the teacher having to be directly involved and allows students to watch the video again if necessary.

Math QR Code Example

A QR code can also be made for a reading station. This simple code accesses an audio file of a book being read aloud. For students with disabilities or students needing remediation, they can listen to the book as many times as necessary to get the content.

Reading QR Code Example

Teachers can also place QR codes on items or in locations outside of the classroom. They could be QR codes with links to educational content or specially constructed websites near things like historical landmarks, parks, an outdoor STEM classroom, treasure hunt, worksheet help, leave codes with people involved with reenactments, or other educational scenarios. Students could scan the codes they find to receive further instructions or clues to lead them to the next QR code, and teachers would be able to track who has scanned which codes. This type of lesson could also be used around a school building.

High School QR Code Example

Conclusion

QR codes offer an endless supply of creative ways for students to learn using technology. QR codes can help engagement during a lesson, manage classroom behavior, and facilitate learning at each student's individual pace. For some teachers, technology can be overwhelming; therefore, it is suggested that teachers try to integrate just one or two QR code activities into their classroom at first. Below are several parting ideas and examples for using QR codes beyond those previously mentioned.

Tool	Ideas with Examples
Create Resumes	Students can link their websites or portfolios that showcase their work and technical writing skills. http://www.edutechintegration.net/p/elective-subjects-resources.html http://www.pinterest.com/pin/130956301637659006/
Showcase student work	Students can link their best work via a PowerPoint or Voicethread for others to view.

	http://coolcatteacher.blogspot.com/2011/05/qr-code-classroom-implementation-guide.html http://educationqrcodes.wikispaces.com/Introduction+To+QR+Codes http://www.autismclassroomnews.com/2013/04/helpers-and-behavior-free-qr-helper.html
Showcase a skill	Students can link a "how to" for others. For example, how to "be kind to others," or how to "feed the class pet."
	http://ilearntechnology.com/?p=4211 http://www.pinterest.com/pin/130956301637659039/
Check answers	Students can scan a QR code and check their work after they have completed an assignment or group activity.
	http://engagetheirminds.wordpress.com/2012/05/01/qr-code-year-end-reflection/ http://eberopolis.blogspot.com/2012/11/word-walls.html http://eberopolis.blogspot.com/2012/04/management-mentoring-monday-assessing.html
Differentiate instruction	Students can listen to different QR codes with tiered instruction.
	http://www.pinterest.com/pin/130956301637659018/ http://wheretheclassroomends.com/non-fiction-lesson http://wheretheclassroomends.com/qr-codes-popular-culture http://www.teacherspayteachers.com/Product/QR-Code-Adventure-Analyze-and-Evaluate-Information-Read-Write-CCSS-634638 http://technologyinearlychildhood.com/freebies/
Extended time on assignments	Students needing more time can listen to instructions, or have material reread as many times as they need to complete assignments.
	http://365hartley.blogspot.com/2011/04/qr-codes-for-kindergarten-1122011-photo.html http://eberopolis.blogspot.com/2012/04/tutorial-use-qr-codes-for.html
Interactive labs	Students can use codes attached to a skeleton or dissected animal to enhance or extend an assignment.

	http://www.periodicvideos.com/ http://thepegeek.com/2009/03/25/learning-the-skeleton-with-qr-codes/ http://www.classtools.net/QR/index.php http://www.edutechintegration.net/2012/11/tuesday-teaching-strategy-gallery-walk.html http://www.thedaringlibrarian.com/2012/01/google-hangout-with-qr-codes.html http://www.scottsibberson.com/2011/10/more-qr-codes-in-science.html?spref=tw&m=1
Vote	Students can vote on anything academic or social. Whether its related to a science experiment or morning routine. Students can even take attendance, lunch information and/or complete morning work via a QR code.
	http://flapjackeducationalresources.blogspot.com.au/2012/08/qr-code-behavior-coupon-freebie.html
Bell work	For some students, bell work is too difficult to accomplish independently. Instead, students can scan and watch part of the previous day's lesson. This provides extra review and minimizes the frustration of not being able to complete work.
Homework	QR codes with difficult problems can take students to explanations, additional practice, or videos for review. This is a great way to get parents to help students with homework for those assignments you can't quite remember how to do.
	http://www.osakajalt.org/blog/2010/12/15/how-i-use-qr-codes-in-the-classroom.html http://eberopolis.blogspot.com/2012/12/qr-code-homework-check.html http://www.teacherspayteachers.com/Product/Reindeer-Homework-Fun-using-QR-Codes-School-to-Home-Connections-953709

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Dialogue and Literacy Instruction: How Technology Can Bridge Equity and Underachievement Issues In Urban Settings

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Abstract

This research project seeks to address the problem of diminishing motivation to read as students progress through school, especially among students of color. Through the creation of quality reading lists that are matched to student interests to drive meaningful conversations, technology plays a critical role in maintaining literacy skills. The research project takes place in an urban setting, with sixth-grade students of color struggling with underachievement. The study incorporates a revised iteration of literature circles by using technology and a class blog. The findings of the research project reveal that creating potent reading lists, providing choice, and utilizing technology can result in increases to the motivation to read.

1. Background

A literacy crisis has been highlighted since the 1980s that has revealed alarming statistics about reading achievement and high school dropout rates, with students of color bearing the brunt of these statistics, demonstrating the necessity for renovating literacy instruction (The National Commission on Excellence, 1983; U.S. Department of Education, 2003). Simply put, the so-called achievement gap is underachievement in virtually all measures of academic measurements when comparing Black and Latino students to White students. In real terms, by eighth-grade, Black and Latino students generally lag behind their White counterparts by two years. Having such disparate results between differing races calls into question the egalitarian tenets of the United States (Jeynes, 2014). Needless to say, literacy instruction takes center stage in this longstanding crisis (National Assessment of Educational Progress, 2013). Having large segments of our society receiving incongruent educational outcomes carries with it not only an economic consequence, but also a political one. Social justice and equity issues rise to the forefront of creating fully informed and literate citizenry within a democratic society.

In this same vein, there has been growing concern raised over the years that higher-order thinking skills are lacking, and children are ill-equipped to deal with an increasingly complex and diverse world. In 1996, the International Reading Association (IRA), responding to troubling reading scores being highlighted for decades through various national tests and reports, came out with a set of standards for teaching a wider view of reading and language arts. These standards were reaffirmed in November 2012 by the National Council of Teachers of English (International Reading Association [IRA] & National Council of Teachers of English [NCTE], 1996, p. 2). Moreover, one of the many valuable findings of the National Reading Panel was that comprehension is enhanced through purposeful transactional strategies (U.S. Department of Health, 2000).

2. Literature Review

Over the course of the last 100 years, a number of educational theorists and researchers have made important inroads that directly relate to dialogic approaches as they relate to literacy instruction and beyond (Dewey, 1916; Johnson & Johnson, 1975; Rosenblatt, 1978, 1982; Vygotsky, 1962). In a thorough literature review by Reznitskaya et al. (2009), consisting of a large group of various professors associated with a number of universities, the effects of dialogic interactions were studied, concluding that educators should be teaching students how to think, not what to think. Consequently, dialogue can increase learning opportunities and comprehension, as well as increase overall enthusiasm and motivation to read (Applegate & Applegate, 2010; Avci & Yuksel, 2011; Casey, 2008; Certo et al., 2010; Flint, 2010; Jennings & Mills, 2009; Klinger et al., 1998; Mills & Jennings, 2011; Moley et al., 2011; Pearson, 2010).

Several researchers, however, highlighted the more controversial and problematic aspects of the use of dialogue in the classroom. For example, Clarke and Holwadel (2007) noted that teachers need to be aware, especially in diverse settings, of racial or economic class tensions when implementing a dialogic process. Moreover, students can essentially go through the motions, not truly engaging in critical analysis (Ferguson & Kern, 2012). Finally, the utilization of dialogue, especially upon initial impressions of a text, can actually reinforce stereotypes and myths (Thein et al., 2011).

Based upon the overall research and theoretical support, however, it is safe to say that dialogue is a critical and necessary component of authentic literacy instruction. Moreover, this research suggests that challenging children in thoughtful ways is critical to their becoming lifelong readers. It is through this thoughtful approach that the motivation to read may find its realization. When students are motivated to read, they more easily obtain the research-demonstrated abilities that come from active engagement with literacy (Reznitskaya et al., 2009). Thus, thoughtfully challenging youth, and carefully guiding them through a dialogic process in their literacy development in the classroom, will create more adaptability to the ever-increasing challenges our world faces in the 21st-century and beyond.

Today's literacy zeitgeist is change. Evolving technologies and demographics influence what it means to be literate. Given these continual technological changes, any current iteration of literacy education must acknowledge the all-encompassing impact that technology holds, as compared to generations past, upon student's comprehension (Lankshear & Knobel, 2011).

3. Research Question

When incorporating a discursive component to literacy instruction, the ensuing conversation can only be as good as the text, or other media, which incites thoughtful responses. Therefore, the research question asked, will crafting quality reading lists increase the motivation to read by constructing an opportunity for relevant and meaningful discussion?

4. Target Audience

Choosing participants for this research project occurred from within a sixth-grade classroom located in the greater Minneapolis metro area. The school district of the participants serves over 20,000 students and is the fifth largest school district in the state of Minnesota. The school itself serves prekindergarten through sixth-grade. There is an active English Learner (EL) program at the school, serving those students whose first language is other than English. The school focuses on closing the so-called achievement gap for its 90 percent plus students of color.

Within the particular classroom in which the research project took place, there were 24 sixth-grade students. During the one and a half hour literacy block, however, only 13 of those students remained in the classroom. The other students who did not participate in the research project were pulled out to take part in various special education classes, EL, Title I, or Read 180 literacy interventions. From the remaining 13 potential students, other difficulties arose such as non-compliant behavioral issues or student turnover. Ultimately, only those students who began and participated in the literature circles to their completion were counted as full research participants. Ultimately, nine students took the pre and postreading attitude survey, thus considered having fully participated in the literature circles. All but one of the nine students who took part in the research project was assessed to be reading below grade level, especially in comprehension. The nine research participants were four males and five females. The ethnicities of the students broke down as follows: six African American, one Asian, and two Latino. One of the students participated in EL while another received special education services.

5. Project Description

To achieve the goal of creating a reading list that resounded in particular ways with the diverse sixth-grade classroom, a reading interest inventory was first employed (Hildebrandt, 2001). These data were graphed to help gain a data-driven picture of the interests of the diverse classroom. The researcher then chose 75 books, spanning 15 genres from IRA award-winning book lists, explicitly increasing the chances of book resonance among the students. In this way, the qualified reading list served as a worthy platform from which to support effective reading choices for implementation of literature circles in the classroom. The resonant reading list found fruition through student choice from this qualified list of books.

Literature circles served as the dialogic teaching model for implementation within the classroom. Prior, and subsequent to the implementation of literature circles, students were given a reading attitude survey (McKenna and Kear, 1990). This information helped inform the success of the booklist in producing discussion and any consequent boosts to reading motivation. The pre and postreading reading attitude surveys were compared with a Wilcoxon Matched-Pairs Signed-Ranks test to see if there was a statistical difference between the pre and posttest reading attitude scores. As part of a triangulation, exit interviews were employed, and patterns were sought to supplement the quantitative data.

6. Method

As noted in the literature review section, literature circles, especially in diverse environments, can present a number of challenges as outlined in the research of Clarke and Holwadel (2007), Ferguson and Kern (2012), and Thein et al. (2011). As it turned out, this held true for this particular sixth-grade classroom. In particular, the students had significant problems in conducting effective and meaningful two-way conversations with one another, despite rigorous and explicit modeling and practice. To remedy the situation and adapt to the needs of this particular classroom, the researcher incorporated technology into the literature circle discussions by implementing them online, through a class blog. To this end, 18 Chromebooks at the researcher's disposal that were already being implemented across the curriculum were readily utilized as part of the literature circle discussions. Each day, the students would formulate a response to the day's reading. They would then respond to others' reactions, which in turn led to more discussion and reaction. Blogging thus proved quite successful in helping the student’s discussions, as they were able to overcome the various difficulties and aversions they had with face-to-face conversations, spawning valuable interactions that might not have happened otherwise.

7. Implementation Results and Reflection

Examining the pre and postreading attitudes using a Wilcoxon statistical analysis revealed a statistical significance between the pre and postliterature circle attitude surveys. In short, the results did support the research question, finding that discussion, carried out through technology, did appear to increase the students' overall motivation to read.

Table 1
Wilcoxon Matched-Pairs Signed-Ranks Test Data

Student	Ob 1	Ob 2	Signed Rank 1	Signed Rank 2
1	13	69		4.5
2	27	52		2
3	48	48		
4	17	79		6
5	90	66	1	
6	30	98		7
7	37	93		4.5
8	8	40		3
9	33	25	1	

Table 2
Wilcoxon Matched-Pairs Signed-Ranks Test Results

T	*N*	*z*	p(*z*)
3	8	-2.100420126	0.0356919

In an effort to triangulate the data, an exit interview was given to the students in written form, with written responses. In keeping with the theme of the literature circles, where a class blog was initiated to garner reactions, the exit interview allowed students to think about and formulate their responses. These data also showed favorable results in all five categories examined (overall discussion, the book itself, level of interest, comprehension, and reading excitement). All nine students found the book talks engaging, with the implementation of the literature circles being credited with an increase to their excitement of reading. Eight of the nine students found their book to be intriguing, with the literature circles holding their overall interest. Seven of the nine students felt that literature circles, and their subsequent online deliberations, helped them understand and comprehend the book better.

Some of the more noteworthy comments have been included to give texture to the exit interviews, such as one student's comment regarding the blogs themselves, "I think it is cool sharing what happened in the book and see how others feel about the book." About the book choice process and their subsequent book selection, students' opinions were made clear with words such as, "the best, exciting, good, amazing, and interesting." One student, in responding to the level of interest the book held for him, replied, "In Quarterback Season, totally, because I was a quarterback in 3rd grade." Recounting the ways the blog discussions helped their understanding and comprehension of their book, another student responded, "Well, when you have other people's perspectives of the book, you get to see the book from more points of view." More students went on to say, "People don't think of the book the same way I do," and "It makes me question myself." One student summarized the value of the discussion by stating, "[It] made me know more things." The research question was then posed to the students themselves, seeking their opinion about whether the literature circles made them more excited about reading. One student encapsulated what the data was showing with, "Yes, it's a way of talking to each other using the thing you love - computers."

8. Limitations

Due to the small number of available participants resulting from the complex and diverse circumstances of the school, the results of the study are somewhat limited, framed within the context of the specific sixth-grade classroom. Furthermore, the school in which the research project took place was almost exclusively students of color, so producing a larger extrapolation from the findings outside of this context might be difficult. However, publication of this study warrants further future analysis with a larger population of students.

9. Discussion

As technology becomes increasingly ubiquitous in the 21st-century, students will be approaching literacy in many different ways from the past. This research project successfully used technology as an effective alternative to face-to-face interchange, thereby allowing these students to participate in productive discussion that might not have happened otherwise. Furthermore, it makes intuitive sense - that if students are allowed to choose from quality books that match their interests, and then are allowed to talk about those books with peers using technology, that increases to motivation will naturally occur. Moreover, in the case of this research project, technology brings a certain level of familiarity to students of the digital age, thus increasing the likelihood of providing more relevant reading experiences. All of these factors, however, make this project a somewhat cumbersome endeavor to implement within the classroom, especially given today's focus on standards and limited time. That being said, producing students who know how to read and understand is a very different thing than students who want to read. Teachers should strive to move beyond learning to read and reading to learn, to facilitating children who are motivated to read for a lifetime. Students leaving school with a natural desire to read will have an inherent desire to learn, which seems the larger goal of education. Technology appears the likely fit to marry what we know about good reading instruction with the goal of producing students who will read outside of school. The future calls for educators to fashion motivating factors around reading, namely technology, to produce students who will be ready and able to face the many challenges ahead.

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Acknowledgements

Special thanks to Dr. Paulette Stefanick and Dr. Debbie VanOverbeke for all their help and guidance at Southwest Minnesota State University.

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Harnessing Mobile Devices for Ubiquitous Learning in New Zealand Schools: Pedagogical Modalities, Possibilities and Limitations

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Abstract

The New Zealand curriculum states that schools should explore not only how ICT can supplement traditional ways of teaching but also how it can open up new and different ways of learning. Emerging mobile technologies are changing the educational landscape and offer promise of innovating instructional delivery. Most of the growing body of research in mobile learning has been conducted in the United States of America, Europe and Asia. Little but growing research evidence is available in the New Zealand context. The research study described in this paper explored how mobile devices can be used as a tool for learning in New Zealand primary schools. A mixed methods approach involving surveys and semi-structured interviews was used in conducting this study. Participant students were aged 10 to 13 years of age and came from two urban Auckland schools that have been using the mobile devices for a period of twelve months or longer. Although the implementation of mobile learning in these schools is still in the early stages, the students alluded to the ease with which they could access knowledge online when they needed it. They also felt that using mobile devices enabled them to improve their learning in the classroom and at home. However, students did highlight some concerns such as the possibility of theft of devices and the lack of robustness of hardware infrastructure in their schools to support mobile learning.

Introduction

Schools that are moving to implement mobile device initiatives aim to have every student 'connected'. Excluding the 'fad factor', experts say there are legitimate reasons for educational interest in mobile devices. They have long battery life, are lightweight, extremely portable, have less start up time and cost effective. A mobile device has a simple design that offers pervasive learning of anytime, anywhere learning opportunities. Harlow, Cowie, & Jones, (2008) claim mobile devices cater for diverse learning styles and differentiation, which increases motivation and enthusiasm. Alton-Lee (2003) supports this claim stating teachers can optimise learning opportunities for diverse students by using digital devices which support the use of diagrams, movies and photos. Anderson (2006) states that teachers report greater engagement, more collaboration and increased autonomy in lessons that integrate mobile devices.

In short, mobile devices are a new advancement in education. Research will determine the value of the device as a tool and the effect they have on student learning outcomes. Recent research on mobile learning based in New Zealand is limited, but this is growing. A recent survey conducted throughout New Zealand schools did give a good indication that a small number of mobile devices are used or school leaders are thinking about implementing them into their schools.
The study described in this paper examined the ways children within the 10 – 13 year age group use mobile computing devices in their learning. The study adopted a mixed methods approach involving a combination of a constructed questionnaire and semi-structured interviews. The questionnaire explores student perceptions of pedagogical practices embedding mobile devices that will enhance learning in the classrooms. The semi-structured interviews of students will examine the impact of mobile devices on learning engagement, collaboration and autonomy levels in the classroom environment.

Literature Review

Melhuish & Falloon (2010) state there is interest around the potential of mobile devices to support a liberalisation of learning, based on their ability to support individuals to construct knowledge by connecting with others to 'produce, consume and store content and conversation. They emphasize however that educators must see beyond the hype surrounding a device - to inquire into how effective it might be in terms of promoting long term, deep learning. Excluding the fad factor, experts are saying there are legitimate reasons for educational interest in mobile devices. Many researchers see the potential of wireless mobile learning devices in having a large scale impact on learning because of their portability, low cost and communication features along with increased battery life and less start up time (Banister, 2010; Chan et al., 2006; Crompton, Goodhand, & Wells, 2011; Quillen, 2010).

The internet and wireless technologies enable mobile devices to interconnect with other computing devices seamlessly. Seamless learning implies that a student can learn whenever they are curious in a variety of scenarios and that they can switch from one scenario to another easily and quickly using the personal device as a mediator. The mobile device's computing power also connects it with other facilities used in the classroom, such as whiteboards. The human being and mobile device interact in multiple ways, benefitting both teachers and students in the process. The mobile device becomes a valuable resource that puts knowledge and learning literally into the hands of all students (Crompton, et al., 2011; Liu, et al., 2003).

Students in schools can access data, create and publish their own work at a faster rate and it is centered around authentic learning (Kinane, 2012). The popularity of such classroom learning highlights the importance of flexibility in the education system. The classroom becomes more learner centered, assessment centered, knowledge centered and community centered (Roschelle, 2003). The use of mobile devices in the classroom has extended the idea of flexibility to new frontiers (Aqib & Asim, 2012). Mobile devices enable the teacher and students to utilise their computing power anytime, and anywhere.

Mobile technologies are increasingly 'woven' into students' lives nowadays (Melhuish & Falloon, 2010). In many ways, mobile technologies or mobile learning (m learning) challenge the constraints of institutional and traditional pedagogies - the position and role of teachers in this process becomes increasingly important. If mobile devices are to be ubiquitous in education and serve as a catalyst that could facilitate movement towards constructivist practices, teachers need to be professionally trained to act primarily as coaches. Generally, teachers who have used mobile devices in their classes report greater student engagement, more effective collaboration and increased focus on lessons (Anderson, 2006; Katie Ash, 2012; Collins & Halverson, 2009). Their role now shifts to being a mediator, supporter, facilitator or guide of learning. (Liu, et al., 2003; Tatar, et al., 2003).

Methodology

A mixed methods approach was adopted for the purpose of this study. One hundred and thirty students took part in an online survey about their use of mobile devices in the classroom. The students were aged 10 to 13 years of age and were from classes where their teacher indicated they were using mobile devices in the classroom. The students completed the on-line survey. They came from two urban Auckland schools that have been using the mobile devices for a period of twelve months or longer. One of the schools is a primary school, catering for students from Year 1 through to Year 6. The second school is a large intermediate school with a similar multi- cultural ethnic mix.

Students were selected randomly from the participating classes to take part in the semi-structured interviews. Alphabetical class lists generated from the school's student management system were used for the random sample. Every sixth student on the class list was invited to participate in a semi-structured interview. The students had the right to refuse participation and it was strictly on a voluntary basis. Fifteen students took part in the interviews. The semi-structured interviews solicited their views on the multi-faceted aspects the mobile device and the impact it made to their learning. The mixed study approach adopted allowed for both qualitative and quantitative data to be generated and cross-referenced for triangulation purposes to better understand the ways in which mobile devices were used and the nature of the interactivity between these devices and learning occurring in the classrooms. Using such a mixed methods research design allowed the two forms of data to integrate, forming links and subsequentially enabling more consistent findings to emerge (Creswell, 2012).

Results & Discussions

The first question asked if they brought their own mobile devices to school. Fifty six percent responded to owning their own mobile device. Of that 56%, 80% owned iPods and 13.5% owned iPads. Of all the students surveyed, 5.5% had their own laptops. A further 34% said they used school-owned mobile devices in the classroom. Nine percent of those surveyed said they did not own a device and did not want to use one in the classroom.

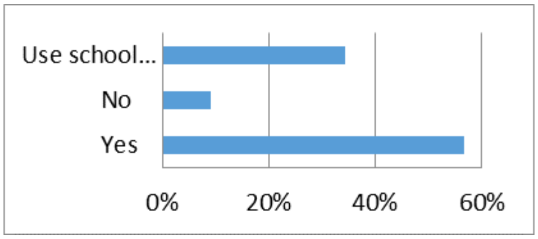

Figure 1. Student use of Mobile Devices at School

The reason for the large number of apple products used in the schools was due to initial parent consultations. The purpose of the parent consultation meetings was to demonstrate the utility of mobile devices in action - showing their functionality and versatility in the hands of students. There were also opportunities for questions from parents. During these meetings, the schools in the study requested that only Apple™ products or laptops with specific specifications be brought in for personal use. The results are shown in Figure 2.

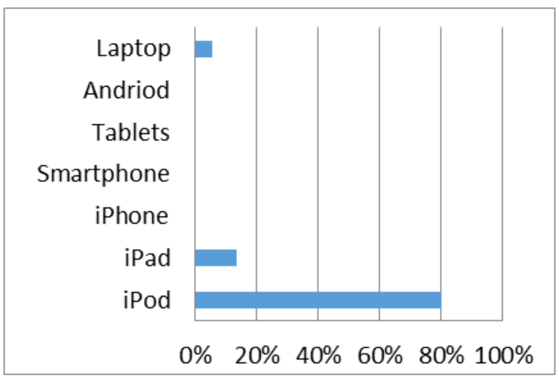

Figure 2. Devices used in school.

The push towards uniformity in the devices to be used was made to make it easier for senior school leaders and ICT technicians to initiate the implementation of the mobile devices scheme. Smartphones and iPhones were not an option in this introductory stage, as all phones are banned in the schools. Senior school leaders stated that these policies might now need reviewing as there is a school-wide thrust towards allowing students mobile devices in the classroom.

The second item in the survey asked students when they used their mobile devices the most throughout the school day. Sixty percent responded that they used their mobile devices in numeracy to varying degrees – predominantly engaging in practice and drill activities. When interviewing the students most of them talked about the enjoyment and engagement they had when using a numeracy application, which supplemented the work they had done with the teacher in the classroom.

In other classes, literacy or word study applications were used by 70% of the students. The overall result of when students used their mobile devices in class is shown in Figure 3**.**

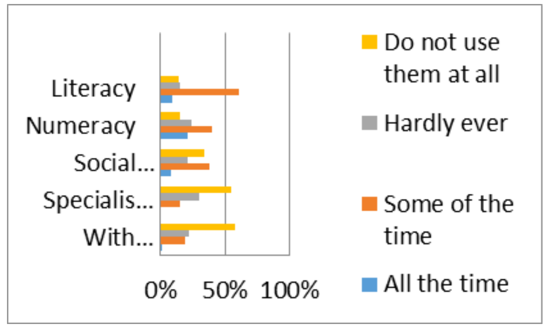

Figure 3. Mobile Device use per subject area

The survey indicated that nearly 80% of all respondents listed using mobile devices for research activities - gathering information and answering questions quickly. Almost half responded that they used their mobile device as a dictionary, thesaurus and calculator. A small number, 20%, indicated that they used their mobile devices to read eBooks and play games while they were at school.

Meaningful learning takes place through learner interactions with the mobile device and peers within content rich contexts. Many assumptions are made that students are highly skilled in using the devices. When interviewing some of the students it was surprising that many of them had not owned or seen an iPod or iPad before being introduced to them at school. Over 60% of the students commented that a teacher or peer had taught them the basics of how to use the device. They felt that using these applications had made some improvement to their learning.

The responses to the next item indicated that most students use their mobile devices when told to by their teachers as shown in Figure 4. The students indicated that they would like to have more freedom in using their devices and discovering applications that support their learning.

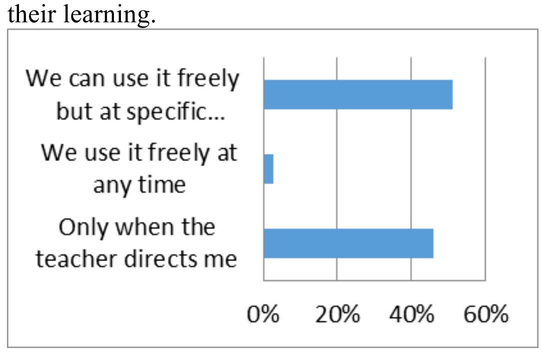

Figure 4. Freedom to use Mobile Devices

Only 2% of respondents said that they were able to use their devices freely but were unable to download and use applications of their choice while they were at school. This shows a need for a shift in teacher pedagogy to a more student centred learning one where students are given greater autonomy to navigate their own ways through the learning space.

Some students commented that they do not bring their mobile devices to school every day because the teacher does not use them or let them use it; once again, a change in pedagogical practice will be needed before the full potential of mobile devices can be realized.

Figure 5 shows that many students felt that the mobile device had helped them with their learning. 62% agreed that the use of a mobile device had improved their learning. They said that the device challenged them to improve their scores when 'playing games' and it gave time restrictions which enhanced their thinking time and recall abilities. They believed that earning rewards whilst 'playing' educational games, helped them to stay focused for longer and practice their strategies for learning.

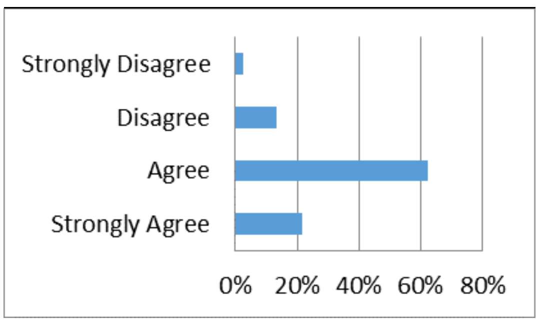

Figure 5.Mobile Devices that improve learning at school

Students commented that they liked to listen to the eBooks and follow the text. They felt that this was another way of positive engagement. Bonk (2010) believes that Digital books on mobile devices will move a significant chunk of learning out of traditional classroom settings and promote the 'blended learning' approach.

The key elements of a 'blended learning' approach includes elements of learning with others, reflection, knowledge and practice (Dyke, 2007). The students who were interviewed commented that by using mobile device in groups they were able to collaborate with others and link with other groups outside of school. Peers don't need to live down the street anymore, they could be anywhere in the world (Bonk, 2010). Mattila & Fordell (2005) state that mobile devices support student's thinking and actions, but the equipment alone will not do the learning. The learning still takes place in the learner's own head. Having small groups of students explore the never-ending benefits of using mobile devices, allows the teacher to have some control of what and how the mobile devices are used in the classroom and yet foster learner autonomy. Teachers are able to allow students to discuss with each other face to face as well as exchange individual material through the mobile devices (Liu, et al., 2003).`

Some educational experts believe that to realise the benefits of new technologies, teachers need to start preparing themselves with new pedagogies (Park, 2011; Reid, et al., 2006). The students in the project voiced their opinions around their learning and frustrations around being directed to use their mobile devices. Only 2.7% of the students believed they were free to use their mobile devices when they wanted to, which equates to 97% of the students waiting for the teacher to direct them in using them. Although students did not comment on their teachers' instructional delivery styles, they did indicate that they would like to have time to explore what their device could do and have choices in the ways they approached their learning.

Almost 90% of all participants in the project commented on the ineffective infrastructure in the classrooms. The students, from one school in particular, all made comment of the frustrations and anxiety they experienced when using their mobile devices. They commented on having to log on several times during a lesson and became frustrated when using the internet to research. They mentioned that it was slow and they weren't sure if their work was saved correctly. Teachers felt that the ineffective infrastructure made the students despondent and they had to revert to basic pen and paper style learning and some did not bother bringing their mobile devices to school.

For mobile devices to be used as a tool to support learning, students must be able to access reliable internet connections. Research stresses the importance of building and maintaining proper infrastructure to ensure classrooms where mobile devices are used can connect to the internet smoothly (Anderson, 2006). A wireless audit by experts should be completed. The infrastructure must be working well before the mobile devices are introduced. An ineffective network creates high levels of frustration for staff and students (Kinane, 2012).

Mobile device initiatives will have every student 'connected' and provides opportunities for students to be engaged in innovative learning approaches. Students commented on the ease of transporting mobile devices from home to school and the robustness of these devices. One student articulated the following in the interview:

> "*I like bringing my mobile device (iPod) to school as it is light and I can keep it in my pocket. I like to listen to music which my teacher lets me do while I am working, and I can listen to music on the way home from school"*

The touch screen interface of the Apple™ products is friendly and can be learned quickly by even the younger students. It is intuitive, responsive and highly motivating. The motivational aspect was highlighted many times throughout the study.

Students liked the way the mobile device allowed them to use different representational modalities in their work. The mobile device allows for photos, videos and music to be stored and played back with just a few taps on the screen. When students were asked why they liked using the iPod or iPad, they stated they were easy to use. Aqib&Asim(2012) state that the Apple™ products have the ability to return to the home screen at any time. This function helps students instantly feel at ease with the user interface. It appeals to digital natives because of their need for immediacy of information (Aqib&Asim, 2012). They have long battery life; weigh less than laptops, extremely portable, less start up time and cost effective. Apple™ products have a simple design which offers pervasive learning opportunities anytime, anywhere (Pasnik, 2007).

Concerns surrounding use of mobile devices

In the study students were asked if they had concerns about the implementation of mobile devices as a learning tool in their classrooms. In this section, we will examine some of the concerns highlighted in the responses to the online survey as well as individual interviews.

Most of the students (78%) who were interviewed did comment on preferring the iPad to the iPod. They stated the screen size on the iPod was at times difficult to read and they also had difficulties using the small keyboard. Most preferred using a laptop or desktop computer when it came to publishing their work. A small group of students did not mind what device they used especially when working on numeracy applications. Students commented on how 'lucky' they were to be able to use mobile devices in the classroom. They believed they were lucky because their teacher was interested in using mobile devices and they had the opportunities to use them. However, they stated that some teachers did not know how to use the mobile device or knew they were putting up barriers when it came to using mobile devices in the classrooms. These barriers need to be addressed - hence the importance of a school wide culture being established and appropriate professional development being introduced under the abled guidance of an effective ICT leader and senior management (Kennewell, Parkinson, & Tanner, 2000b). Besides mounting regular professional development programs for teachers, programs targetted at students to enhance their digital literacy skills could also be implemented to empower these students to be able to optimally exploit the educational affordances of the mobile learning environment. When both teachers and students are well trained to tackle the challenges posed in having to function in an ever changing landscape shaped by the complexities of emergent technologies, then the immense learning potential of mobile devices elaborated upon in research literature can be readily realized in schools.

Conclusion

Technology offers teachers and students alike a wealth of rich media and information to stimulate thinking in new ways. As technological developments happen at a rapid pace, schools need to be responsive in leveraging upon the affordances of such emergent technologies to foster better pedagogical practices in the classrooms. The efforts aimed at exploiting the potential of cutting-edge technologies in the educational arena need continued reflection and evaluation. The increasing use of mobile devices is still a relatively new concept throughout New Zealand, with some schools allowing students to bring personal mobile devices to schools to be used as a tool for learning.

This study which evaluated the effectiveness of use of mobile devices to support learning activities in the classrooms found that students believe they are benefitting from the integration of mobile devices in their classrooms. The mobile device, in particular the iPod, is like having a 'toolkit' in your pocket, which connects students to a wealth of information. The survey revealed that 56% of participant students owned a mobile device. Most students in the project owned an iPod or iPad. Over 60% of the students who owned devices commented that a teacher or peer had taught them the basics of how to use, interact, upload and download. Approximately 50% of the students had learned the strategies of downloading applications taught to them by a teacher. Students felt that using these applications had helped towards some degree of improvement in their learning. The survey indicated that nearly 80% of respondents linked using mobile devices to the research process i.e. gathering information and answering questions quickly. Students were of the opinion that using mobile devices allowed them to take risks in their learning, ask deeper, higher order thinking questions, and be able to have instant access to information. In summary, using mobile devices in the lessons and classroom activities allowed students to take greater ownership of their own learning. However, students also highlighted some concerns surrounding the implementation of mobile learning e.g. theft of devices and robustness of hardware infrastructure in schools that need to be considered and addressed by educational policy makers and leaders in rolling out mobile learning initiatives. Overall, this study underlines the growing focus in harnessing the power of mobile technologies to engage students in their learning in more meaningful ways and foster innovative instructional practices in the classrooms.

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Appendix

Student questionnaire

1. Do you bring your own mobile devices to school?
   a) Yes
   b) No
   c) Use the school provided device
2. If 'yes' or if you use the school's one which device do you use? e.g ipod, iphone, ipads, tablets, androids….
3. In which subjects do you use your mobile most?
4. Rank them in the order of extent of usage (1= all of the time to 4= not using them at all)

Numeracy (Maths)	Literacy (English)	Social Science and Topic work	Specialist subjects (Technology or other teachers)

5. What are the ways in which your mobile devices are used for learning in your classes?
6. How freely are you able to use the mobile devices for your learning?
   a) Only when the teacher instructs us
   b) We can freely use anytime
   c) We can freely use when allowed to by the teacher
7. Do you think that using your mobile device has helped to improve your learning at school?

Strongly Agree	Agree	Disagree	Strongly Disagree

8. If you 'strongly agree' or 'agree' how has it helped you at school?
9. What are the positive benefits in using the mobile device during lesson time?
10. In your opinion, what way can using mobile devices for learning, during lesson time, be improved?

Student interview questions:

Student interview questions that were asked to supplement survey data:

1. Explain how you learned about the capabilities of your mobile device
2. What activities do you use your mobile device for?
3. How different is your classroom with the introduction of mobile devices

Teaching Introductory Programming by Course Merger

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Iqra University

Abstract
Curriculum update is a mandatory process. Sometimes, management does it to squeeze the number of credit hours as per accreditation requirements. This reorganization may introduce some shortcomings in the curriculum. For example, it may deprive students of professional competence (skills required for a job), essential project related skills and some core computing concepts. This study presented a scenario in which the Computer Engineering Department (CED) removed the Computer Graphic course (CGC) from its curriculum. To overcome this deficiency, instructors integrated selected contents of CGC within the Introductory Programming Course (IPC). However, this course fusion did not compromise the IPC's course outline. Overall, the course merger results were satisfactory. Students attained the necessary Computer Graphic (CG) orientation.

1. Introduction
Accreditation authorities often ask universities to improve their curricula. One reason can be to reduce the number of credit hours to bring programs up to par with international standards. This may deprive students of several useful courses. These courses though may not be in-line with the fundamental theme of the program but they impart valuable skills, which are both required for obtaining professional competence and familiarization with essential computing concepts required for developing the final year project (FYP). In this context, Sir Syed University's CED recently removed the Computer Graphics Course (CGC). This study shows how course instructors used an innovative approach for teaching the Introductory Programming Course (IPC). They merged it with the Computer Graphics Course to overcome its deficiency in the (Engineering) Curriculum. Surveyed literature does not illustrate this theme in the IPCs.

Normally students have to undertake remedial courses by taking part in vocational training institutes to overcome the curriculum limitations. This is both a time-consuming and expensive solution. This paper explores the idea of integrating the contents of the deficient course with some other course in the curriculum. In other words, instructors amalgamated two courses into a single course. The advantage, in this particular case, is that it would not violate the guidelines of the accreditation committee as per total credit hour requirement for the Computer Engineering discipline. However, this combining process should be judicious. It should not marginalize the importance of the main course, which was IPC in this case. At the same time, it should not neglect the Computer Graphic Course even though it was an elective course. The troublesome issue is that the main course and the elective course may have varied levels of complexity and this can put a big question mark on the merger. For example in this particular case, CGC was previously a course in the third semester of the Computer Engineering curriculum while IPC must be taken in the first semester.

The IPC-CGC merger was wholly a faculty initiative; i.e. neither the board of studies nor the chairperson of the department recommended the merger. In this context, introductory programming is the master course i.e. the main course, while CGC is the dependent course i.e. the course combined to the master course. The research presented in this paper tries to address issues such as switching between the two merged courses, exploring the pre-requisites for the merger, achieving the teaching and lab interaction of the upper graded dependent course (i.e. CGC) topics without diluting the ingredients of the lower graded master course (i.e. IPC), and finally student satisfaction for this merger. Coverage of the master course was not part of this research because it was implicit that students could not develop the project without achieving proficiency in IPC.

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The IPC-CGC merger was wholly a faculty initiative; i.e. neither the board of studies nor the chairperson of the department recommended the merger. In this context, introductory programming is the master course i.e. the main course, while CGC is the dependent course i.e. the course added to the master course. The research presented in this paper tries to address issues such as switching between the two merged courses, exploring the pre-requisites for the merger, achieving the teaching and lab interaction of the upper graded dependent course (i.e. CGC) topics without diluting the ingredients of the lower graded master course (i.e. IPC), and finally student satisfaction for this merger. Coverage of the master course was not part of this research because it was implicit that students could not develop the project without achieving proficiency in IPC.

2. Background and theoretical Framework

In the engineering profession, the product development process incorporates principles from various trades. Thus students must know the fundamentals of chemistry, physics, thermodynamics and any other related engineering disciplines. Due to the application of concepts from several domains, the engineering curriculum consists of courses from various engineering as well as non-engineering disciplines. However, credit hour restrictions result in compressing several courses into a single course. This is a common practice as discussed by Choate (2005). They created a hybrid thermal fluid course of four credit hours. The subjects were enrolled in the non-mechanical engineering majors. This course actually acted as a replacement to the three four credit hour courses taught in the Mechanical Engineering (ME) curriculum. This development of a hybrid course in ME discipline can be used as a guideline to incorporate deficient courses into other engineering disciplines.

As discussed earlier, students often enroll in vocational training institutes to overcome their weaknesses. This is a source of additional burden on parents. In the United States as discussed by Repenning (2012), educationists discourage the after-school teaching of programming concepts even at the middle school level because of their perceived reduced impact. Instead, they opt for the integration of a specialized Computational Thinking curriculum into the middle school. Furthermore, they introduced a game design project, which brought interest in the learning process. Though this example is related to school-age children, it clearly projects the bleak picture of vocational courses, generally due to their horrible schedule. Indeed these courses lack depth of content and are often delivered by persons lacking university degrees. However, not all are so awful. Some vocational training institutes associated with multinational software houses are known for their quality but again they are very expensive. Thus, these courses are suitable for employed people who want to upgrade their resume or for persons who want to refresh their professional skills after a gap of several years.

2.1 Utilizing Constructivism to Teach CG Contents

Due to time constraints, it was not pragmatically possible to deliver the lecture contents of two courses in the duration of a single course. An effective strategy needed to be devised. The IPC course instructor employed 'social constructivism' (Kalina and Powell, 2010; McCaslin and Hickey, 2001) for this purpose. In this approach, the instructor had to adopt the role of facilitator rather than that of a teacher (Jackson and Klobas, 2008; Adams, 2006). Instead of giving lengthy lectures on CG topics, the instructor facilitated students building their own understanding of the content. He assigned the topic, defined its boundaries, and provided web location addresses so that students can get access to books and handouts related to the topics.

This change of role implies that the instructor needs to possess a completely different set of skills than that of a conventional teacher. A teacher tells, a facilitator asks; a teacher lectures regularly in a class; a facilitator provides random checkups and cleverly hides himself most of the time, the teacher often indulges in spoon feeding but a facilitator provides necessary resources and creates the environment for the learner to arrive at his or her own conclusions (Biggs and Tang, 2011).

2.2 Utilizing Project-Based Learning Approach

Constructivism is a general approach and requires an instrument for translation into pedagogy (Pelech, 2008). The idea that springs into our minds in this context is a project based learning approach. This approach fits in the current research as we want the learning process to flourish in an unsupervised manner. The activity is initiated by the teacher by assigning a general, complex real world task to the students. Students are responsible for exploration, investigation, working in groups and sharing their knowledge, task delegation and assigning specific roles to the group members, and then these members apply their knowledge and skills, and work as a cohesive force to achieve their target (Bas, 2008). They have to apply their intelligence for project completion and this enhances their knowledge. During this period, the teacher ensures proper utilization of skills of all group members and substantial information exploration. Finally the teacher evaluates the project for originality and completion. Learners can also evaluate themselves and can exhibit their projects in the school, to let other students evaluate them. The critical goal is to enable student(s) to become a creative, intellectual thinker and problem solver with less dependence upon the teacher. Thus due to the shortage of time for CG content delivery, two different strategies were adopted to minimize the role of a teacher and to incorporate self-study habits among the students. The first strategy was to assign a calendar/planner project to students so that students "learned by doing" (Schank, 1995) rather than depend on the instructor's "spoon-feeding." The second strategy was to assign CG's theoretical topics to student groups and each student group (comprised of four students) had to give a presentation on that topic. This situation is similar to the 'Jigsaw Classroom' (Brown and Campione, 1994; Eilks and Leerhoff, 2001), where a student group becomes 'expert' in a particular CG topic and teaches it to the rest of the class.

3. Merging CGC with IPC

The objective to incorporate CG contents in the IPC forced the instructor to decide about three important issues: the programming language to be used, the selection of topics and the delivery of these topics.

3.1 Programming Language

The first issue relates to the usage of the tool or the programming environment for this endeavor. The surveyed literature shows several studies aimed at teaching CG in the first year of an undergraduate program. Most of these studies focused on the use of graphic tools such as AutoCad, QuickDraw and so on as discussed in (Noorani, Rodiguez, Givens, Christensen, & Foyos, 2007), (Stephenson, 2009). The previously taught CGC at the department incorporated Visual Studio 2006 in the first half and 3D Max in the second half of the semester. On the other hand, IPC usually concentrated on the 'C' language throughout the semester. Thus to avoid digression in the IPC, the instructor employed Visual Studio. The advantage is that this tool (i.e. VS 2010) has a rich CG library.

3.2 Selection of Topics

Before going into the details of the selected CG contents for integration in the IPC, the authors want to give a brief background of the IPC taught at CED of SSUET. It is basically a 'C' language course taught in the first semester. SSUET's CE curriculum lists IPC as Computer Programing and Problem Solving (CPPS). Initially, there were two CPPS courses (CPPS1 and CPPS2) of "3+1" credit hours each. Their contents are similar to the contents of "CS 1" and "CS 2" (excluding the OOP concepts and commands applied to Unix environment) provided in (Cordes, Parrish, 2002). However, due to the accreditation committee's recommendations, CED merged the two CPPS courses into a single course of "3+1" credit hours in 2009. However instructors involved in teaching the course noticed problems in student understanding. This led to an increase in the duration of the course to "3+2" credit hours in 2010.

On the other hand, the eliminated CGC was part of the third semester CE program. It consisted of topics of a much more complex nature as compared to the IPC and hence needed a considerable amount of time. The instructor's intention was to select topics that were trivial in nature but had significant demand in the job market and yet had a relationship with student projects and fundamentals of CG. However, the selection process could not overlook the following two factors:

1. The constructivist theory (according to which current knowledge is built upon the previous knowledge). It's difficult to teach CG concepts to students when there is no connection with their previous knowledge.

2. No prior programming experience for the entering cohort (Meyer, 2012), thus coaching of advance programming concepts might be difficult to them.

In connection with the above factors, the course instructors selected the following topics for imparting CG knowledge to the students:

Table 1. Selected topics for CGC.

S#	Topic Name	Theory ('T') / Lab ('L')	Outcome in Figure 4 in Roman
1.	2D Image Transformation	L	N.A
2.	Line Drawing Algorithms	L	N.A
3.	Circle Drawing Algorithm	L	N.A
4.	Font Generation	L	N.A
5.	Shading	L	N.A
6.	Displaying Bitmapped Image	L	N.A
7.	3D Effects	L	N.A
8.	Difference: Vector and Raster Graphics	T	i
9.	Dithering (T)	T	ii
10.	Color Palette (T)	T	iii
11.	Image Compression: Lossy vs Lossless, Run Length Encoding	T	iv
12.	Cathode Ray Tube	T	v
13.	Color Models: RGB and CMYK	T	vi
14.	Applications of CG	T	vii
15.	Graphic File Formats	T	viii
16.	Animation	T	ix
17.	Ray Tracing	T	x
18.	Moirre Effect	T	xi

The list in Table 1 omits some other important topics (see Appendix A) due to time constraints. The lab topics, for instance topics # 1, 2, and 3 are very much familiar to the students because they studied these topics in their high school geometry and arithmetic classes (Jackiw, 1997). On the other hand, topics # 4, 5, 6, and 7 are important from the project point of view. The main reason for the inclusion of the theoretical topics #8, 9, 10, 13, 15, 17 is to make the students familiar with the latest terminology of the CG field. The remaining selected topics are trivial in nature but are important to understand the underlying technology of CG.

3.3 Deliverance of Topics

Due to time constraints, it was not pragmatically possible to deliver the lecture contents of two "3+1" credit hour courses in the duration of a single "3+1" credit hour course ("3+1" means 3 hours of theory and 3 hours of lab work). There were some other barriers also such as no previous interaction of students with computer science/computer engineering courses, and their lack of programming experience. At the same time, the IPC's course outline restrictions also prevented the instructor from imparting CGC knowledge in a lecture style.

In IPC, the main focus is on language constructs, its syntax, and fundamental programming concepts. This surely has to be done in a conventional lecture-lab style format so that the beginners can get enough information, hands-on experience and supporting examples to grasp these topics. Instead, CG issues such as algorithm comprehension, simulation of real world objects, and familiarization with coloring codes were not part of the original IPC course outline, so it was not justifiable to discuss them in the lecture. This means it's necessary to augment some other strategy to propagate the learning process of the CG topics. The strategy followed in this paper was to motivate the students to study these topics on their own using the CG textbook (Hearn and Baker, 1996) and the web links provided by the instructor. Some teachers may criticize this approach of pushing the lecturer behind the scene and for exposing new entrants to complex third semester CG contents. Normally in a university environment, instructors engage students in self-study habits by asking them to give presentations and to develop projects. This is particularly useful to make students ponder those topics which may lapse due to time shortages and which don't have any significance from the examination context. A recent study discusses that the demand for presentation skills in the engineering profession is increasing (Arias et al., 2013). This work shows that audiences' comments and corrections at the end of group-based presentations helped in improving students' grades. However, this work does not explore the application of presentation skills in the context of unsupervised learning. Thus, following the group-based strategy of the above-mentioned work, the instructor divided the students into groups of four and assigned them theoretical CG topics in the twelfth week, for preparing presentations. These presentations were due on the first day of the preparation week.

4. Calendar and Planner Project

The above-mentioned real world project focused on developing calendars and planners. The modified IPC lab work was meant to develop CG insight into the students. Each month of the planner required incorporation of a graphical image. This differentiates the project from the work done in (Sooriamurthi, 2009). Figure 1 shows the output of the sample code illustrating the required design of the planner for each month of the year (in this case February 2011). Students had the liberty to alter this sample output but the obligatory requirement for the project was the production of thirteen graphical images - twelve for the planner and at least one for the calendar. The calendar follows a usual style. That is why the author has not included its design.

The planner required the students to incorporate graphical images achieved programmatically. There was no restriction on what to portray in these images. Indeed, their main objective was to act as a bridge for leading the new CE group of students into the world of computer graphics. Thus, the project provided a means to alleviate the CGC deficiency problem without depending upon the traditional lecture style.

Initially, the instructor asked student groups to develop calendar-planner projects. After the culmination of the project, students demonstrated their work. Figure 2 depicts a sample calendar picture. At this point, the instructor assigned each project group to focus on one particular graphical feature displayed in the graphic portion of their planner as well as in their calendars for study purpose. Later on, students were asked to prepare themselves for a 15-minute presentation: 10 minutes for the slide discussion and 5 minutes for the Question-Answer (Q-A) session on that particular graphical feature incorporated into their planner and calendar in a week's time. Students made the slide content from the textbook prescribed by the instructor along with the material available on the web. During the Q-A session, the teacher noted down any unanswered questions by the group. At the end of all presentations the next day, the teacher held a summary session discussing unanswered and ambiguous topics. After that, students filled out a form [Appendix B] to highlight their views about the course.

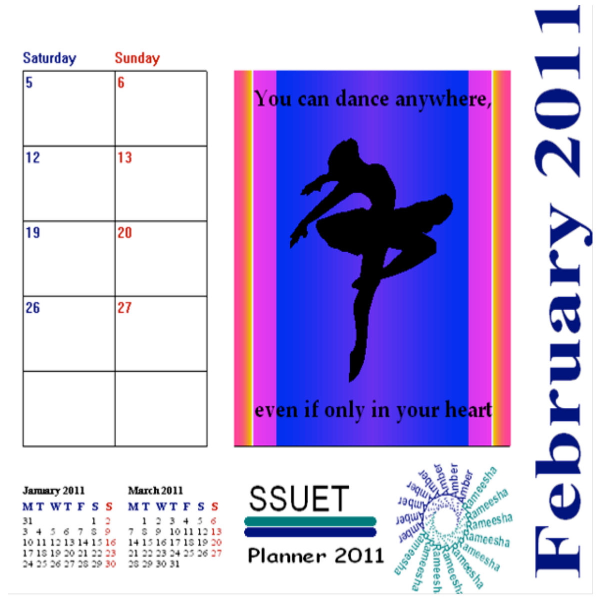

Figure 1. Screen shot of page 2 of a student planner.

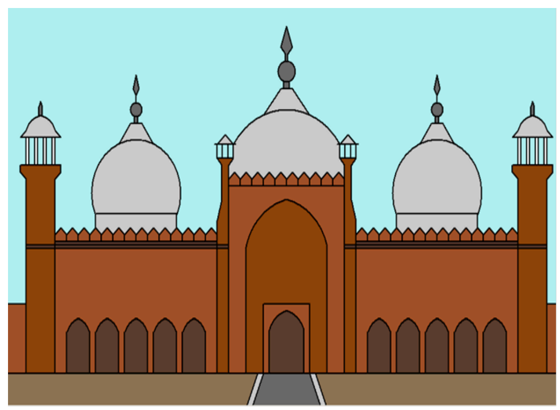

Figure 2. Screen shot of a student calendar showing the Badshahi Mosque.

5. Results and Analysis

In case of the newer/modified version of the IPC course, it was important to assess how the merger had benefited the students. It was anticipated that students would have gained introductory computer graphics concepts and skills while the contents and targets of the original IPC course were also not compromised. The CG contents were examined through two presentations: the first one on a theoretical topic of CG and the second one on the calendar/planner project.

In the case of the project, the student work was demonstrated with the help of a calendar/planner exhibition, which was held in Sir Syed University on the twentieth of May 2012. Around 24 student groups demonstrated their projects. A large number of students, faculty members and other professionals attended the exhibition and most of them praised the students' effort.

The non-CGC programming concepts and material were assessed through class tests, a mid-term exam and a final course exam. The C programming contents of the IPC course remained unchanged and therefore the performance of students on the final exam and other tests was hypothesized to not decline. Final exam results of the IPC course for the years 2010, 2011 and 2012 are given in Table 1. 2012 was the year when the new IPC course was introduced.

Table 1. Average marks of students in the last 3 IPC final exam.

Average Marks in 2010 (out of 60)	Average Marks in 2011 (out of 60)	Average Marks in 2012 (out of 60)
33.2	31.7	36.65

Table 1 demonstrates that there was no decline in students' performance as a result of merging CG contents in to the IPC course. In fact, the performance of students has improved in the year 2012 when the contents of CG were part of IPC. The IPC final exam did not include questions related to the CG topics. Therefore the results indicate that the inclusion of CG contents has not affected students' knowledge and skills of the original IPC content. For the above data, t-test value is 1.654 and p value is 0.0998 and the result is significant at $p < 0.10$.

To address the specific CG needs of the CE students, the student outcomes were developed in concert with various instructors of the IPC course. The teachers who had taught CG in the third semester were required to help in this process. Their help provided useful insight that enabled narrowing down the CG contents. The selected CG contents were compact enough to be covered in a short duration of time through a blend of supervised and unsupervised learning. The student outcomes for the CG contents of the IPC course are listed in the "student self-assessment survey" form given in Appendix B.

The goals of the CG contents are to provide students with a reasonably good experience and knowledge in the stated outcomes and a level of competence with these outcomes. The CG-specific outcomes reflect intended exposure to the appropriate terminology and principles for further study and also the application of CG techniques and Visual C++ commands to create a simple CG-based project.

The 46 students completed the student self-assessment survey form (Appendix B). Five students' forms were discounted because they returned the form in less than two minutes. The forms were meant to determine the success of the CG contents in enabling them to achieve the CG familiarization, with a 0 indicating no mastery and 10 meaning very proficient. Self-study habits imparted computer graphic knowledge to the students instead of lecturing. Therefore, it was necessary to set a reasonable target score for various outcomes of the CG contents. The first 6 outcomes (of the "student self-assessment survey" form given in Appendix B) correspond to the topics covered in IPC labs. The instructor devoted reasonable time to these topics and students also employed them in the calendar-planner project. Therefore, the target score for the first 6 outcomes has been kept 6.0 while the target scores of all the parts of the seventh outcome (related to theoretical concepts) has been kept 5.0 because the material of these topics was given for self-study and not covered in great detail during lecture time.

The instructor assessed student performance on these outcomes via student grades in the two presentations: one on the calendar-planner project and the other on the theoretical CG topics (not covered through class lectures). The results of the student self-assessment survey and the instructor's grade based assessment of the course outcomes are shown in Figure 3 and Figure 4. The results indicate that student performance, assessed by the instructor (through grades) and by the students (through self-assessment survey), achieved these CG contents' targets. In fact, in many cases the results are better than the target set.

Figure 4 indicates that the assessment of the instructor was more relaxed and lenient compared with the students' self-assessment. This may be due to the modest self-assessment of students. The students may have gained knowledge but may not have felt confident enough to give themselves high scores in the self-assessment survey. One student attributed this to the comments and criticism they had encountered at the end of presentations. Of course, induction of presentation content in future courses on a regular basis can act as a confidence building measure in this regard.

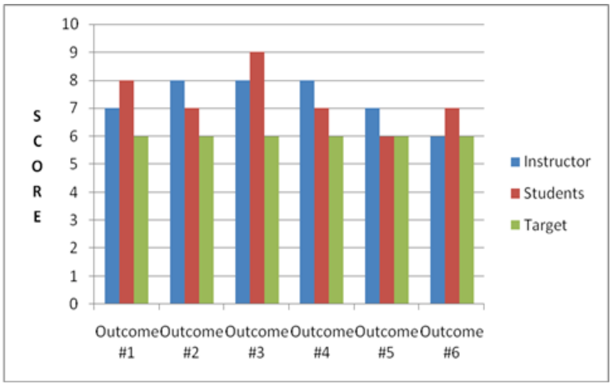

Figure 3. Outcomes Assessment of lab-based CG contents.

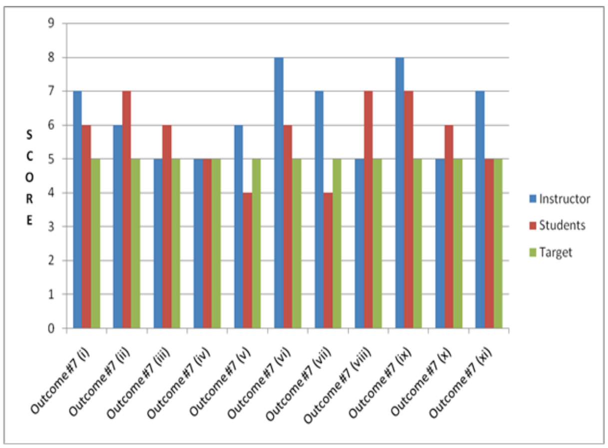

Figure 4. Outcomes Assessment of theory-based CG content.

As far as written outcomes of self assessment forms are concerned, most students answered the first 2 questions correctly. They remembered the arguments and object oriented technique to invoke the methods. But the shapes were limited to squares as the students did not use the 'Polygon' method. Question 3 was also straightforward but less than thirty percent were able to write the correct arguments. Question 4 and 6 were easy as they did examples related to shading and 3d shape representation in the lab. But again, the majority of the students were not able to reproduce satisfactory work. Image drawing was a difficult question and involved lot of steps so it was expected that majority will not be able to write correct commands for it. However some students write the steps in pseudo code form. Overall performance was not so much dismal as Visual C++ is a tough language and use of object-oriented style in the first semester is also a debatable topic.

6. Conclusion

The demand for higher education and vocational training is increasing. At the same time, technology is growing at an enormous pace especially in computer related professions. Topics related to fundamental concepts and vocational training aspects must be incorporated into the curriculum for the sake of student competence. In order to achieve this competence issue without increasing the course count (or overall credit hours) in the curriculum, faculty must develop innovative techniques. This paper shows how we can integrate CG contents within the IPC course. This is an economical and cumbersome free solution. Merger can increase students' load but it should be viewed positively as indicated by the comments of one of the students taking this course: "Albeit, the course kept us busy most of the time but the accomplishments were beyond our imagination". However, topic selection needs careful consideration. Overall results were satisfactory. Students attained the necessary CG orientation while the original IPC contents were not undermined. Future work would be to merge the remaining contents of CGC (not included in this endeavor) with the 'Simulation and Modeling' course to strengthen the above findings.

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Acknowledgements

The author is thankful to his students of Batch 2011 section 'D' for participation in this research.

Appendix A

Original Contents of Computer Graphics Course

Computer Graphics applications, Hardware/terminology, 2D drawing, 2D transformations, Font Generation, Shading, Displaying Bitmapped Image, Difference: Vector and Raster Graphics, Dithering, Color Palette, Image Compression, Lossy vs Lossless, Run Length Encoding, Surfaces, Ray tracing, 3D drawing, Coordinate systems, 3D transformations, Shadows, Color/color models, Shading models, Rasterization, Animation, Computational geometry, 3D rendering, Supporting data structures/models, Texture mapping, Clipping, Antialiasing, Fractals, Pipeline details, Photorealistic methods, Virtual Reality, Global illumination, Projections, Scientific visualization

Appendix B

Student Self-Assessment Survey

Form: Introductory Programming Course (IPC)

Semester: First

Review the course outcomes listed below and state if the course did or did not meet the course outcomes using a scale of 0 (can't do at all) to 10 (very comfortable doing).

1. Explain the four different types of 2D image transformations. What are the Visual C++ commands to implement these transformations?
   Score: ___
2. Apply line-drawing, polygon drawing and circle-drawing algorithms to create useful geometrical shapes
   Score: ____
3. Understand and apply font-creation functions in making of useful computer graphics.
   Score: ____
4. Explain the concept of shading in computer graphics. What are the Visual C++ commands for shading?
   Score: ___
5. Can the bitmapped image displayed through Visual C++ commands? What are the specific commands? Apply the commands to create good graphics.
   Score: ___
6. How can 3D effects incorporated in computer graphics? What are the Visual C++ commands used?
   Score: ___
7. Briefly describe the following terms (only theoretical knowledge is sufficient):

i. Difference: Vector and Raster Graphics
   Score: ___

ii. Dithering
Score:___
iii. Color Palette
Score: ___
iv. Image compression
Score: ___
v. Cathode ray tube
Score: ___
vi. Color Models: RGB and CYMK
Score: ___
vii. Applications of CG
Score: ___
viii Animation
Score: ___
ix Graphic File Formats
Score: ___
x Ray tracing
Score: ___
xi Moirre Effect
Score: ___

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Perceptions of Coding with MIT App Inventor: Pathways for their Future

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Abstract

This paper reports findings from a study conducted in an 8th grade classroom in the south. The study sought to understand teachers' and students' perceptions of using MIT's App Inventor to teach computational thinking, while exploring the viability of offering integrated mobile app development units in middle school classrooms. Students created apps aligned to science standards to answer essential questions about fossil formation. The teacher perceived the experience as valuable believing it positioned her students to learn content and hone computer science related skills. Findings suggest students were interested in learning how to create apps, despite having limited experiences before the unit. Students believed developing apps made learning content more interesting. While students considered coding the most challenging part of app creation, after the unit a majority perceived coding skills as attainable and viewed computer-related jobs more positively.

1. Introduction

"We learned, like coding helps with pretty much every career path you take. Cause coding, it, makes, it… it makes your brain think about how everything functions ~ Madison, 8th grader after developing her first app."

MIT App Inventor (also referred to as "App Inventor") was created with educators and learners in mind, with a goal of increasing interest and skills in computational practices (Pokress & Veigra, 2013). MIT App Inventor [Beta, Version 1] (http://beta.appinventor.mit.edu/) is a free visual programming platform that allows users to create Android apps by snapping blocks together like puzzle pieces. Conceived as an easy entry into intuitive, incremental and logical programming, it consists of two main elements: a Design view used to select components of an app, and a Blocks Editor to program behaviors (Pokress & Veigra, 2013). Google originally developed and maintained the software in 2010. In 2012, Massachusetts institute of Technology (MIT) began hosting and developing the web-based platform. In December 2013, after our study, MIT released the most recent version of the software (http://appinventor.mit.edu/explore).

As a new tool, App Inventor has limited but growing research exploring its capacity in college classrooms (Wolber, 2011; Abelson, Morelli, Kakavouli, Mustafaraj, & Turbak, 2012) with teachers in summer camps (Hsu, Rice, & Dawley, 2012) or its potential to bring computational thinking (CT) to K-12 students (Morelli et al., 2011). Findings have been positive, however the research is typically predictive and aimed at informal learning environments (Roy, 2012), high school students, or college undergraduates in computer science programs. Our study sought to explore the feasibility of integrating App Inventor in middle school classrooms.

Our interest in App Inventor stemmed from research supporting game and app design as a viable options to hone problem solving, logic and reasoning, systems thinking, and creativity (Gee, 2007; Klopfer, Osterweil & Salen, 2009). Adolescents are clearly interested in games and apps (Lenhart et al., 2008), and App Inventor may offer students a pathway to future STEM careers; careers that the job force demands, and lacks, in the United States (Grover & Pea, 2013). At the same time, few states have adopted computer science standards for high school or middle school students (Computer Science Teachers Association [CSTA], 2011, p. ii), meaning extensive computer science curricula or courses are seldom offered to this population. Adding to the difficulty in increasing adoption of computer science courses, most adolescents remain disinterested in computer science believing the courses teach basic literacy practices, are too difficult, or are not relevant to their lives (Cuny, 2012). Women in particular rarely consider computer science careers (Christian, Corbett, & St. Rose, 2010). Stereotypes of computer scientists as unattractive, geeky, socially awkward and overly focused on technology and computers further serve to dissuade adolescents from entering the field (Cheryan, Plaut, Handron, & Hudson, 2013).

Efforts are underway to change the perception and field of computer science. Introductory college courses have considered how interdisciplinary, computational problem solving can entice a broader range of students to consider computer science knowledge and practices as relevant to their future careers (Guzdial, 2003; Forte & Guzdial, 2004; Garcia et al, 2010; Baochuan et al, 2014). New guidelines for computer science now include measures to consider computational thinking (CT) as a universal skill for all 21st century citizens not just computer scientist.

Computational thinking was initially defined as a set of thinking practices characterized by conceptualizing ideas, engineering solutions, and thinking at multiple levels of abstraction (Wing, 2006). In 2011, ISTE (https://www.iste.org) and CSTA defined CT as a problem solving process that included formulating problems in a way that allows a computer to solve them; logically organizing and analyzing data; data representation and abstraction; identifying, analyzing, and implementing efficient and effective solutions, and generalizing and transferring these problem solving processes to a variety of problems (Barr, Harrison, & Conery, 2011). The definition was further refined to include practices that support developing computational artifacts, including teamwork, creativity, and human interaction with computers (The College Board, 2012). Overall, the skills encompassed within CT are markedly different than traditional computer science skills of decades past that were narrowly focused on knowledge and skills related to technical programming (CSTA, 2005).

The fundamental need for computer science knowledge in an information-based society is being reframed as a need for everyone to learn CT (Yadav, Mayfield, Zhou, Hambrusch, & Korb, 2014). Ostrachan (2012) portrays coding as a metaphor for CT, detailing the ways writing and interpreting code is integrated in everyday life. Coding has recently gained popularity as a way to encourage CT as evidenced by large-scale initiatives such as Code.org which hosted CS Education Week (http://csedweek.org/) in December, 2013, introducing coding to more than 31 million students.

This research seeks to add to the body of research on integrating technology into classrooms. In particular, we seek to offer insight into the integration of computational tools into classrooms to teach CT. Since context and conditions matter to effectively scale innovation in schools (Clarke & Dede, 2009; Coburn, 2003; Geijsel, Sleegers, van den Berg, & Kelchtermans, 2001), and teacher attitudes determine how deeply technology is integrated (Angers & Machtmes, 2005; Ertmer, 2005; Hutchison & Reinking, 2011; Lucas & McKee, 2007), we discuss the context of our research intervention while describing the perceptions of teachers and students involved in an app development unit.

2. Goals of the Study

Our goal was to explore how students and their teachers would perceive CT, and coding in general, when offered as an app development unit. We drew on Google's Computing Education articulation of CT as a set of techniques that include: problem decomposition, pattern recognition, pattern generalization and algorithm design (https://www.google.com/edu/computational-thinking/index.html). This articulation of CT more narrowly defines the essence of computational thinking outlined in Barr and Stephenson's (2011).

The scope of the study is aimed at measuring teacher and student perceptions while understanding the logistics of bringing App Inventor into classrooms, working within curricular and structural constraints. We hoped it would lay the foundation to consider integrating App Inventor into requisite subject areas to teach and measure the development of CT to larger populations of students. Thus we created a mobile app development unit that aligned with current science curricular standards and worked with a science teacher to integrate it directly into her science classrooms. Our research questions were:

(1) What are teachers' perceptions regarding integrating app creation into middle school classrooms?
(2) What are students' attitudes and beliefs about coding and computational thinking? Do they change after participating in app-design curricula?

Our research was conducted in two separate eighth grade classes, taught by the same teacher. The research was preceded by a smaller study in two at-risk 8th grade classrooms in a nearby school district. This earlier pilot focused on understanding the technical, logistical and pedagogical considerations to iteratively refine the experience for the current research (Author, 2014).

3. Research Context

3.1 Data Sources and Analysis

Our measures included pre and post-test surveys from students, observations, and student created artifacts (apps or accompanying materials to create apps). Survey questions were developed to address students' beliefs about computer science in general, whether they believed they were good at computing, their interest and experience creating apps, and to gauge if they had prior knowledge of CT. Additionally, short video segments recorded students' perceptions during the unit. Seven students from each class, chosen by their teacher to represent a range of academic abilities, were interviewed in focus groups at the culmination of the unit.

Interview data, field notes, email exchanges, daily conversations and a teacher log provided insight into the teacher's perception of using App Inventor to teach CT.

Codes were generated in two ways: data was coded according to pre-determined themes on pre and post-surveys, and simultaneous data collection and analysis (Merriam, 2014) guided code and theme generation from field notes, observations, interview responses, and teacher logs. These gauged participants' perspectives and practices and were mapped to survey codes or to suggest emergent themes. Student artifacts served to verify the process and completion rate of the apps. Inter-rater reliability and member checks (Stake, 1995) further substantiated findings and allowed us to reach consensual validation. Naturalistic generalizations (Creswell, 2007) were drawn from patterns and themes within the case. The study was completed in the fall of 2013. Below, we briefly describe the context of the case and participants.

3.2 Grant Middle School

Grant Middle School (GMS) is a magnet school in a moderately sized southern city with approximately 830 students drawing from a diverse population. The student body is 57% white, 24% black, 12% Hispanic, and 7% are Asian, Native American or other. More than 40% of the student body qualifies for free or reduced lunch, and the school's "magnet status" attracts a gifted population of nearly 35%. It also serves a special education population of just over 10%. Students enter GMS as 6th graders and nearly 99% stay for all three years before attending a local high school. Our study included two 8th grade science classrooms taught by the same teacher, whose pseudonym is "Brandy".

4. Brandy's Classroom: Using App Inventor to Teach Science Concepts

Brandy has been teaching eighth grade science for eight years. She is organized, enthusiastic, adept with technology, and has an easy rapport with her students. She had observed younger students using App Inventor in a summer camp unrelated to this experience, but had not taught app development. She also attended a 2-day App Inventor workshop hosted by our research team aimed at secondary teachers a month prior to the unit. Brandy appeared excited about the possibilities for app development in her classroom after the workshop, emailing "I had so much fun last week working with App Inventor....can't wait for my students to get here so we can start the process. Looking forward to working with you all!"

4.1 Preparing for the App Inventor Unit

At the end of the previous school year, we met with Brandy and a small team from GMS to discuss the technical and pedagogical considerations for using App Inventor with her students. The school principal, library media specialist, and technical support technician attended the meeting, which resulted in additional meetings with technical support to ensure access to App Inventor. It was determined that school-owned laptops would be prepared over the summer (downloading the software, unblocking websites, setting up student folders) and remain in Brandy's classroom for the 4-week, 12 session unit. Our research team provided Google Nexus tablets and worked with technical support to ensure Wi-Fi access.

Twice during the summer months, Brandy met us to formalize the integration of App Inventor with her science curriculum, choosing a fossil unit to design the experience. Her typical schedule consists of 5 science classes where she reteaches the same content. We decided that our research team would take the lead teaching the first two 50-minute class periods of the day, offering Brandy an opportunity to participate, observe and offer improvements, then she would reteach the lesson three more times after we left. Additionally, Brandy consulted with our team via email, online document sharing, and phone to finalize unit goals and accompanying resources.

4.2 The Participants and Classroom

Fifty-seven students, 33 girls and 24 boys, across two separate classes participated in the study. Thirty-eight students identified as white, 9 African American, 3 Native American, 3 Asian, 1 Hispanic and 3 multi-racial. Brandy was the only teacher participating in the study, however the school's library media specialist often visited the classroom and was instrumental in helping ensure the technology worked. The fossil unit was sanctioned by adopted state and local curriculum standards and offered each fall. Students researched essential questions such as: "How do fossils form?" or "Where are fossils found?" or "What are the different types of fossils?"

4.3 Creating an App to Teach Others about Fossils

Within the 4-week fossil unit App Inventor was taught 3 times per week and science content was taught the two remaining days. Students used their fossil research to plan and design a story-telling app including pictures and text supporting their essential question, with buttons programmed to move from page-to-page on the app. A desktop sized mat (see figure 1) designed to scaffold CT skill development, emulated the various panels and components in App Inventor to help student storyboard, plan, and code their fossil app.

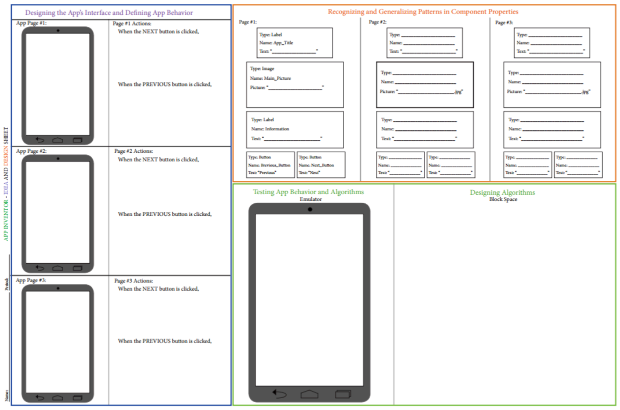

Figure 1: Computational App Design Mat

A typical class period included a 10-20 minute mini-lesson using the mats or other learning resources, followed by 25-30 minutes of students working in App Inventor at their individual computers. Towards the end of the unit, students spent the majority of their time at their computers working on coding, play-testing, and problem solving. All (n=57) students completed a working app. Figures 2 and 3 depict representative student work.

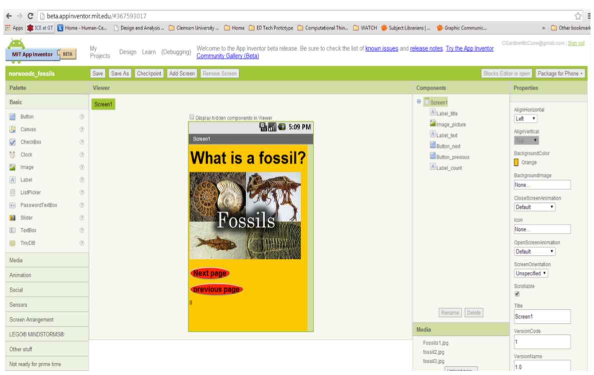

Figure 2: Screenshot of student's app in Designer view using MIT App Inventor

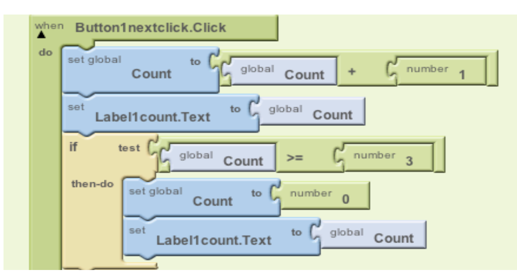

Figure 3: Student coding in Blocks Editor view of MIT App Inventor.

5. Findings

5.1 Teacher Perceptions

In pre-unit planning sessions, Brandy expressed enthusiasm over the possibility of using App Inventor with her 8th graders as she believed previous classes were motivated and highly engaged in anything related to social computing or creating with media. She was open to making changes, learning with her students, and suggesting improvements as the unit progressed. She frequently reminded her students that creating apps was novel, encouraging them to learn from each other.

Themes which emerged in Brandy's written and spoken comments are categorized below outlining her perceptions of (1) the flow daily lessons; (2) student engagement and behavior; (3) value or lack of value of App Inventor, including perceptions of computational thinking; and (4) suggestions for improvement.

5.2.1 Flow of Lessons

Brandi believed starting with an "easy" app, Hello Purr (http://appinventor.mit.edu/explore/content/hellopurr.html), provided on the App Inventor website allowed students to feel successful and capable. Following this app, students made an app using various animal pictures and sounds. The "storyboard mat" was introduced to assist in designing, discussing, and remembering the components of each app and how their interactions. Along with individual science notebooks typical of Brandy's classes, she believed the tools crucial in assisting students to conceptualize, discuss and reference concepts related to each app. While she was comfortable with the open-ended projects – students were asking different essential questions and designing different apps, she believed at times students required step-by-step instructions and tutorials matched to various parts of the app development process. She felt app development became too complex to learn through exploration or guided demonstrations.

Students' third, and final app, was a fossil app which was purposely more individualized, more difficult than the prior apps, and not detailed on the App Inventor website. Brandi again pointed to the importance directing the flow of each lesson with appropriate scaffolds (media, mini-lessons, storyboarding mats, collaborative work, iterative design and peer or instructor feedback). As students worked on the fossil app, most clearly struggled to grasp more complex concepts and became frustrated, yet Brandi commented that they persisted by helping one another saying, "The students have been great to work with, just like I told them…this is a learning process for us. We work together, if I can't figure out a problem a student always steps up and helps."

5.2.2 Student Engagement and Behavior

Brandy insisted participation in the unit yielded positive behaviors insisting her lower-level learners were more focused and engaged than they had been during previous science units. Classroom observations and video review verified that students typically were on-task and appeared engrossed in their work. As the unit progressed, she believed many students mastered app development and felt proud of their work and ability to code, and this in turn influenced their work habits and behavior. She thought the process of creating apps influenced her students' engagement with science content as it offered creativity, inspiration, and group collaboration. Brandi attributed the engagement to increased learning about the content.

5.2.3 Value of App Development

Brandy deemed the experience valuable because students were able to visually represent an idea or process to solve a basic problem. When asked directly about whether she believed it honed CT practices, Brandi pointed to the vast majority of her students using their science notebooks and mats to break down a problem or task into small, more manageable parts (decomposition). She stated that students took the time to learn what each part meant in the design view, making it easier for them to recognize the patterns being used in the blocks editor. She believed the vast majority of her students could successfully break down problems in order to recognize patterns in their coding (within the blocks editor), allowing them to track and solve problems, or make each part of their app functional.

Brandy believed the unit assisted students to think critically about the content (fossils) as well as designing and solving problem while creating apps. She perceived app creation as valuable, believing it provided students with a foundation to consider courses or careers involving visual programming. During the unit Brandy created numerous instructional materials supporting learning, made revisions, and committed to re-teach the unit the following year in her classroom and other District classrooms. She frequently commented on the need to be flexible and embrace change with digital media.

Brandy perceived the skills honed in app development as new, useful for the future, and achievable, saying, "This program allowed students to experience different aspects of innovation, technology, and entrepreneurship through student-constructed learning."

5.2.4 Perceptions Toward Improvement

Brandy made a number of suggestions to improve the unit. She recommended scaffolding the difficulty level when teaching coding by gradually introducing more complex skills. She proposed an intermediary step of creating an app with a "few more components" before moving to the "final" complex app requiring numerous components, choices, and multiple types of code blocks. She suggested ways to use the storyboarding mat introducing concepts incrementally so students were less overwhelmed. She also believed it was critical to have students write detailed notes for portions of the code-writing so they had a model to look at, proposing, "Have students take notes for a step-by-step process. I think the students can analyze the process by taking notes and then using their notes to construct the app." She frequently discussed the need to use tutorials, student notebooks, or written directions to guide or check their work.

Six months after the unit ended, Brandy sent an email saying her students continued to discuss the various characteristics they learned while coding, citing the experience as "an educational moment that changed their and my view points of technology." Her future plans to continue using and scaling app development were apparent in her log entry:

"Week 4: This has been an amazing experience that I hope to carry out for years to come. I am currently interested in other district positions, one being an instructional coach. I would love to have that job next fall and work with teachers to start this program in classrooms."

5.3 Student Perceptions

Student pre and post-survey, interview and observational data were used to indicate findings related to student perceptions of the experience. First, we briefly summarize student experiences with app creation and perceptions of CT before the unit. We then include tables with responses comparing changes in student perceptions regarding computer jobs, programming/coding, and perceived computational abilities after completing the unit. Summarized focus group interviews provide a broader perspective of the experience.

5.3.1 Limited Prior Experiences with App Creation

Only six students, 4 boys and 2 girls, had previous experience with coding or app design through summer camps or other family members. Pre-surveys indicated a majority of students, N=34, were interested in learning the process of app design. Seven students hoped it would help them with a future career in coding, another 7 cited "humanitarian efforts" or benefitting others, 7 listed improving computer skills as their goal, and 1 student simply wanted to get a good grade. When asked what it meant to think computationally, a majority of the students responded, "to think like a computer," "to think technically," or "to code or program". A few responded with "think broadly," "think analytically", or "think outside the box," and a few did not respond or said they were unsure.

5.3.2 App Inventor Impacts Student Perceptions of Computational Thinking and Computing

At the completion of the unit, students were again asked, "What does it mean to think computationally?" A majority of students responded similar to their pre-unit questionnaire citing "think like a computer" or "to code or program." However, a notable change in responses included nine students who included the following to conceptualize computational thinking: analysis, problem solving, applying new knowledge, drawing out a plan before doing it, logical deduction of facts to determine an answer, brainstorming ideas to make an algorithm, analyze and solve problems rationally, and methodologically and strategically form an outcome." Transcribed focus group data demonstrated that many students could articulate how they used CT when developing apps. For instance, when posed with a definition followed by a question such as, "Decomposition means you break down a problem into a smaller more manageable problem. Did you do that when you were using App Inventor?" Representative student responses included:

> So at one point I lost some of my stuff on blocks editor and instead of freaking about thinking the whole situation about half of my App has gone down. I just thought about rebuilding it page by page and I broke it down into smaller parts and that helped me get through it faster.

> We used the mat and it broke it down for us. We had our views, and placed the images and labels and everything, and we could use the next button and it broke it down for us step by step, so that we could figure out how to go through this process of making this App.

Student surveys further demonstrated pre and post perceptions regarding beliefs about computers in general, programming, computer jobs, and their computing capabilities. After the App Inventor experience, 75% of students perceived computing was fun (n=43). More students considered programming less difficult (35%, n=20). Fewer students perceived computer jobs as boring (37%, n=21), and overall students felt better about their current ability to compute (12%, n=7). However, while more students responded positively to "I am good at computing", six students no longer felt they could "become good at computing" after the unit and 3 additional students decreased their perception of future computing ability from strongly agree to agree (11% overall shift, n=9).

Table 1. Programming is hard:

	Pre-survey Responses	Post-survey Responses	Change
Strongly Disagree	0	7	+ 7
Disagree	1	14	+13
In Between	39	17	-12
Agree	11	12	+ 1
Strongly Agree	6	7	+ 1

Table 2. I like the challenge of computing:

	Pre-survey Responses	Post-survey Responses	Change
Strongly Disagree	1	2	+1
Disagree	7	11	+4
In Between	17	13	-4
Agree	16	18	+2
Strongly Agree	18	15	-3

Table 3. Computer jobs are boring:

	Pre-survey Responses	Post-survey Responses	Change
Strongly Disagree	0	16	+16
Disagree	21	15	- 6
In Between	15	20	+ 5
Agree	6	3	- 3
Strongly Agree	15	3	-12

Table 4. I am good at computing:

	Pre-survey Responses	Post-survey Responses	Change
Strongly Disagree	3	1	-2
Disagree	16	11	- 5
In Between	22	26	+ 4
Agree	10	10	--
Strongly Agree	6	9	+ 3

Table 5. I can become good at computing:

	Pre-survey Responses	Post-survey Responses	Change
Strongly Disagree	0	1	+ 1
Disagree	0	5	+ 5
In Between	10	8	- 2
Agree	24	27	+ 3
Strongly Agree	23	16	- 7

5.2.3 After the Unit: Perceptions of App Development as an Important Skill

Post-unit surveys showed 66% of students believed programming with App Inventor was fun (n=38). Moreover, students overwhelmingly (75%, n=43) perceived the unit as valuable making learning the content more interesting. Only 1 student believed the unit was not valuable," 51 students disagreed or strongly disagreed with the statement that "it was a waste of time." Transcribed focus group (n=14) data showed similar results; students repeatedly discussed app development as a valuable skill for their future and pointed to wide-ranging careers in healthcare, science, engineering, IT, entertainment and gaming that might benefit from CT skills.

Fifty-three percent of students reported wanting to find out more about computing (n=30) on the post-survey. This represents a stark increase from 11% of students reporting an interest in computer science before programming with app inventor (n=19 as measured on the post-survey). Moreover, 44% of students (n=25) reported an increased interest to take a programming class in high school after the unit based on their experience with app Inventor.

Student enjoyment of programming was not without challenges, yet many students deemed the unit a "worthwhile challenge." Most students suggested the unit changed their perception of what computer science entailed; one student said he would most likely not continue to develop apps.

One student described how she felt at the end of the unit:

> Mary: "At the end of it…it was kind of bittersweet because you have victory of making an app that works, and you know, looks nice and everything, but then it shows that the, there is a lot of work that goes in just a simple app, so if you were to make like a complex app it would take a lot…..and a lot of coding."

James described the challenge of coding in App Inventor:

> "I liked to be challenged. Like I was challenged in this app but if I am challenged and I work towards a goal and I make that goal and then I lose it again, I'm not really interested in trying."

Bethany followed Jamie's comment with:

> "That's like tackling a puzzle. You've got a perfect puzzle. You are not making the puzzle, the puzzle is already done but then someone chops the puzzle into different pieces and then you got to go put the puzzle back up again, then they see that you've got the puzzle back again and they chop it into different pieces again and you have to put it back together."

6. Discussion

6.1 Student Interest and Perceived Future Ability

Students in this study were clearly interested in developing apps, expressing excitement and motivation to begin the unit, because they had knowledge of app use outside of school, and were interested in learning the process of app development. In this case, their limited experience with programming, coding or app creation did not serve as detriment to their curiosity. After the unit, their confidence with computers and technology remained steady; and they continued to believe they were good at computing. However, nearly 11% of the students no longer felt they could "become good at computing." This may point to some students' beliefs that they can maintain their current level of comfort with computing skills, but learning to code appears less achievable due to the perceived depth of knowledge needed to make more sophisticated apps. This sentiment was most eloquently captured by the quotes from students about the "bittersweet" feeling they experienced after completing their first large app project.

Focus group data and informal conversations with the students suggest their "bittersweet feeling" is also a result of their initial aspirations to make more complex apps once they finished with this project. In essence, the experience of actually coding the app for their project may have calibrated their perceptions about their own computing abilities and brought them more in-tune with their current computing ability. In turn, this may have caused them to rethink the knowledge involved in continuing to develop future abilities. These findings are aligned with research on other game-based computer science learning programs where students' interest in games, like mobile apps, is not always enough to increase their desire to learn more about computing and to increase their perceptions of future computing ability (DiSalvo & Bruckman, 2011).

6.2 The Importance of Appropriate Scaffolds

Despite this decrease in perception of their future computing ability, 53% of students were interested in finding out more about computing. This implies that the demonstrated decrease in student perceptions toward their future computing ability may have more to do with our approach, that is the lack of appropriate scaffolding around App Inventor (e.g., app development resources, tutorials, and instruction), in assisting students to manage the complexity of building their mobile app. This hypothesis is confirmed by 35% of students reporting a decreased perception of programming as hard on the post-survey but a 12% downward trend of students enjoying the challenge of computing (n=7, measured from the differences in ratings from the pre to post-survey).

Brandy's comments on the flow of the unit, student engagement, and suggestions for unit revisions also point to the need to include materials or scaffolds outside of the app development platform. Her beliefs were affirmed by our weekly classroom observations where it was apparent students needed, and benefitted from, increased scaffolding to understand more complex programming.

In this case, using guided instruction and printed tutorials with text and images allowed instructors to support the introduction of new concepts and blocks in App Inventor, while allowing students to work at their own pace to implement these concepts in their apps. The teacher would then often work with students that needed additional help, or provide other students opportunities to implement optional/advanced features in their apps.

Interestingly, we found that guided instruction and printed app-creation tutorials alone were not enough to support effective CT skill development. This resulted in the use of non-technological tools and instructional practices (e.g., science notebooks and student note-taking to guide tool use) to focus student attention and reinforce conceptual understanding. This suggests that a mixture of technology focused and student note-taking focused activities are needed to support development of computational artifacts when using a new tool/technology in the classroom. This finding aligns with research demonstrating that scaffolding student use of technologies is similar to scaffolding other types of learning tasks, (Reid-Griffin, & Carter, 2004), where learning is scaffolded by the teacher as well as the tools through guided practice (Cazden, 1988).

6.3 The Importance of Engagement

Brandy's beliefs about students engagement with the tools fostering learning the (science) content and honing CT implies educators might benefit from using other game and app development platforms to achieve similar goals, which may offer opportunities to meet individual interests, learning preferences, and styles. Diversifying artifact creation (app or game choices) may provide a less daunting context for students to learn to program, and increase their perceptions of future computing ability.

We acknowledge, for some students coding and CT may simply not be appealing, and thus they may not be responsive to changes in instructional or computational tools aimed at increasing their computing perceptions and abilities.

6.4 App Development as a Viable Approach to Teach Computer Science Skills

Our post-unit findings regarding positive students perceptions towards computer-related jobs, and the impact App Inventor had on making learning the science content more interesting suggests that we may have a viable approach to increasing middle school students' engagement in computer science related skills. Overall, students had a better grasp of CT practices after participating in the unit and their teacher perceived it as feasible way to offer learning experiences with content, CT and computer science skills.

Moreover, their teacher's perception of the experience as valuable through her initial agreement to offer this unit in two of her classes and later extend the learning experiences to three additional classrooms, along with proposing numerous suggestions to scaffold learning and improve the unit, further implies that this may be a viable approach to increasing middle school students' engagement in computing. Teacher perceptions often drive how deeply technology is integrated (Ertmer, 2005; Ertmer & Ottenbreit-Leftwich, 2010) and student perceptions towards computer science related skills, such as coding, should be grounded in their interests, insights and creativity (Repenning, Webb, & Ioannidou, 2010). This implies app development or similar units integrated with curricula may be positively received by teachers and students, and potentially impactful.

6.5 Navigating Curricular and Logistical Constraints

Institutional constraints make technology integration in any classroom difficult. The nature of innovation often runs counter to the reality of schooling, which typically involves separate subjects taught in discrete chunks of time (Shaffer, 2006). Logistics, curriculum requirements, negative attitudes often pose barriers to adoption (Klopfer, Osterweil & Salen, 2009). Yet in this case, few curricular or logistical constraints prevented students from learning requisite content while developing apps. We believe it due to planning far in advance, open communication with the teacher, and the level of commitment from the school providing technology support and sanctioning curriculum integration.

Although Brandi was an engaged and enthusiastic participant in the project, it was her emergent understanding of the importance of developing CT with her students, as well as her ready grasp of the technical skills required, that made her such an effective collaborator and teacher during this unit, even though it was very new to her. This suggests school level commitment is important when piloting and scaling technology-enhanced innovation (Chamberlain et al., 2013), and research on teachers' comfort in learning *along with* students using game or app-based design environments in similar contexts may be fruitful.

Our research demonstrates that open-ended projects can be effective mechanisms for aligning CT with core curricular content and standards for a small diverse population. We found that achieving this alignment required students to work with MIT App Inventor in a few short, fun, coding projects to help them learn the tool and build their confidence and conceptual understanding of how to design apps. This was done prior to applying the tool to a standards-aligned project. In addition, the guiding questions used in the curriculum were open-ended and inquiry based - essential for providing students with a measure of autonomy and choice in their demonstration of curricular knowledge. More structured scaffolds and instructional approaches helped them learn new skills (e.g., CT and coding).

Findings from this study, and our experiences working with other middle school teachers in math, science, social studies, and technology suggests that more research on co-teaching with researchers and other teachers may be beneficial to student learning, teacher confidence, and effectiveness in using new computational technologies in the classroom to support CT and coding in middle school classrooms.

7. Limitations

7.1 Sample Size

Although the study provided important information about teacher and students' perceptions of using App Inventor to teach CT and coding, the sample size was small meaning the findings may have limited generalizability. However, the students who participated in this study were from a variety of achievement and motivational levels, which are consistent with the authors own classroom experiences. Thus, the perceptions and attitudes of students may be representative of middle school students with similar demographics and school.

7.2 Context

An unquestionable limitation within this study was the context in which the unit was offered. That is, a classroom offered the support of three researchers and a highly motivated, tech-savvy classroom teacher. This influence may have positively affected students and student app development as there were more people to answer student questions, student issues were more quickly identified and instruction was quickly adapted to meet student needs. Moreover, the school provided additional technology support assistance as the school's media specialist was available to address network and Internet connectivity issues as they arose during the classroom period. This resulted in providing the teacher and students with more stable and reliable technology access than might commonly be available at other schools. However, research on instructional technology integration indicates that access to reliable technology and technical support is crucial for teaches to effectively integrate technology into the classroom (Dutt-Doner, et al., 2000; Hew & Brush, 2007). Likewise team teaching approaches have also been found to be effective when using technology in the classroom (Ertmer, 1999).

7.3 Time

Scheduling dictated the time allotted to teach the mobile app development part of the unit, meaning the MIT App Inventor lessons were subject to discrete blocks of time, and not taught every day. The other days were used to provide science instruction sometimes related to the project and sometimes on new course content. It is unclear if more, less, or flexible time devoted to the unit would yield different results.

Moving forward, additional studies with larger populations in classroom environments, across subjects and grade levels, with a variety of computational thinking tools would add veracity to this research.

8. Conclusion and Final Thoughts

This exploratory study positions others to develop curricula and instruments scaling practices and research to deem effectiveness to larger populations. It gives educators insight regarding the value of using app design to teach CT as well as the logistical and instructional needs for supporting technology use in the classroom. The implications and suggestions of this research contribute to the advancement of field of digital media and learning in K-12 classrooms.

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How to Best Engage Middle School Students in Computer Programming and the STEM Fields: An Educator's Action Research

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Abstract
I am currently the Information Technology Literacy teacher at Badger Ridge Middle School in Verona, WI. I feel fortunate to have this position during a time when educational resources in the STEM (Science, Technology, Engineering, & Math) fields are rapidly growing with increasingly easy access, including the brand new Code.org curriculum. Code.org is a free Web site which has created a fun, hands on curriculum that inspires students to be interested in the STEM fields and teaches them the basics of programming software. Code.org has been funded by Mark Zuckerberg and Bill Gates and backed by President Obama. One of the main goals of Code.org is to inspire girls and minority students to become more interested and engaged in computer science, STEM fields, and computer programming, areas that statistically have far fewer women and minorities in their professions. Having exposed and guided 450+ 6-8th graders through the Code.org curriculum, I believe it truly does foster students to be more interested in programming and STEM fields, and provides an extra boost for students who may be learning about these fields for the first time.

This summer I taught "Introduction to Computer Programming" for two weeks to a group of ten middle school students. During this course students worked on a sequence of computer programming tutorials beginning with the Code.org curriculum. After they completed the Code.org, they worked on learning the programming languages HTML, CSS, and JavaScript through the Web site CodeCademy. Each day students also completed daily tasks which always included watching an informative video on computer programming and the importance of learning it. Students gained a lot of knowledge and experience with computer programming, and received lots of information about different STEM professions.

In this action research project, I examined what I as the educator can do to further students' interest in computer programming and their interest in pursuing careers in the STEM fields. I especially focused my lessons and activities on those that would engage women and minorities. Fortunately, there are now a number of resources that inspire all students to be interested in computer programming and also feature women and minorities at the same time. By taking detailed field notes and observations each day, and by analyzing the work submitted by the students over the course of their two weeks, I have been able to hone in on the resources and approaches that work best towards this inspiration.

Literature Review
Science, Technology, Engineering, and Math (STEM) are the fields of the future. STEM jobs "Play a critical role in shaping culture and economic development" (Cooper & Heaverlo, 2013, p. 28) and the economy is increasingly dependent on workers skilled in the STEM fields (Lawrence & Mancuso, 2012, p.). Jobs in the STEM fields are growing three times faster than non-STEM jobs and make up 9 out of 10 of the fastest growing fields. Further, they pay 26% higher wages then non-STEM jobs (Cooper & Heaverlo, 2013, p. 28; Milgram, 2011, p. 5). Yet, while women now make up 50% of the workforce, they comprise only 20% of the workforce within STEM fields (Toglia, 2013, p. 15). This review will look at some of the current scholarly literature on why women and minorities are currently underrepresented in the STEM fields as well as steps that are being taken to reverse this trend, particularly with girls at the middle school age.

From 1991 to 2006, women graduating from college with a bachelor's degree in a STEM field have declined, and in 2010 only 8% of girls said they were interested in pursuing an engineering job (Forssen, et al, 2011, p. 46; Lawrence & Mancuso, 2012, p. 11). This statistic is rooted in "historic and invalid stereotypes" that impact how girls view STEM jobs (Cooper & Heaverlo, 2013, p. 29). From an early age, girls have been socialized to believe that certain jobs are for men and others are for women. There is a belief that certain careers are more suited for men, and that boys are better at science and math (Cooper & Heaverlo, 2013, p. 29; Toglia, 2013, p. 15). Further, girls have a belief that you can't have a life outside of a STEM career (Milgram, 2011, p. 5). These beliefs have been reinforced by "skewed portrayals" on TV and in movies (Platz, 2012, p. 29).

The most cited solution for how to engage and sustain women's interest in STEM is through extra-curricular organizations. IGNITE (Inspiring Girls Now in Technology Education), SPIRIT (The Surprising Possibilities Imagined and Realized through Information Technology) and GE2McS (Girls Excited about Engineering, Mathematics, and Computer Science) have all proven successful in nurturing enthusiasm and increasing abilities within the STEM fields for young girls and minority students (Forssen et al, 2011, p. 46; Lawrence, & Mancuso,. 2012, p. 12; Platz, 2012, p. 27). These organizations use a combination of techniques such as presentations, fieldtrips and engaging workshops. One successful approach is highlighting the various STEM careers by having panels of female workers and minority workers discussing their jobs and leading career exploration activities. Girls and minority students really identify by having personal connections with "real life role models" (Milgram, 2011, p. 5; Platz, 2012, p. 27). Girls tend to choose jobs that benefit others and incorporate problem solving, so showing how STEM careers benefit society has also proven successful (Milgram, 2011, p. 6; Cooper & Heaverlo, 2013, p. 30).

It is imperative to begin engaging girls' interest in STEM at an early age. (Cooper & Heaverlo, 2013, p. 29). Introducing STEM to all students in middle school allows for more time to explore the STEM fields and become interested. STEM interests tend to decline in high school girls, but early exposure has translated to a higher success in college (Cooper & Heaverlo, 2013, p. 30; Forssen et al, 2011, p. 46; Platz, 2012, p. 29). Despite these facts, there is little written on engaging middle school aged girls and middle school minority students in STEM during the school day.

For the United States to remain competitive, they must improve STEM literacy in the k-12 classroom (Cooper & Heaverlo, 2013, p. 32). Fortunately, President Obama's Educate to Innovate campaign has provided funding to expand STEM education and career awareness to underrepresented groups including girls (Milgram, 2011, p. 4). Code.org, Hour of Code is one such example of a successful program to come out of Educate to Innovate. Code.org is game-based online activity that teaches kids how to program by incorporating Angry Birds and Plants vs Zombies characters with videos in-between each level featuring Bill Gates, Mark Zuckerberg, and other famous people encouraging students about the importance of learning how to program. Since its debut in December 2013, news outlets report that thousands of girls and minority students have become more interested in STEM as a result of the Hour of Code.

Methodology

Research Setting

I taught "Introduction to Computer Programming" for the Verona Area School District – Summer School Enrichment program. Class was held at Savanna Oaks Middle School in Verona, WI July 7-17, 2014. I taught students who are going into 6th-9th grade. Class was 8am-11:30am, Monday-Thursday for two weeks. We were in a computer lab with 30 computers; my 10 students each choose where they wanted to sit.

Sampling

13 students enrolled for the Intro to Programming course, one of the summer enrichment options available to any student in the district. Of those 13 students, two never came and one only came twice. Of the ten who were there every day, three of them were girls and seven boys. One of the girls was of Indian descent. Two of the boys were black, one of which had moved the previous year from Gambia and had very minimal reading or writing skills. A third boy was Latino, and his mother approached me at the beginning of day one to let me know he knew very little English and was pretty worried about the course. That leaves two girls and four boys who were white. Knowing the race/ethnicity of the students is important, especially when looking specifically at inspiring minority students.

Data Collection

I used a number of tools to collect data during this two-week period. First, I kept a daily log that I filled out throughout class. I wrote down the assignments I gave each day, my interaction with students, my observations of the class and individuals, and any questions or misunderstandings the students had. I would then write down my daily reflections in the journal as soon as the students had left. Second, I had the students fill out a questionnaire on the first and last day of class that focused on their interests and understandings in regards to computer programming (see findings). Next, I had the students keep a daily journal. Students filled this out before break and at the end of the day. They also included a separate entry each day responding to the daily video(s). Finally, one day I had a co-worker, middle school special education teacher Briana Lenzlinger, observe my class for half an hour to ensure triangulation.

Timetable

The Verona Area School District Summer School Enrichment program, Introduction to Computer Programming ran July 7- July 17, 8:30am-11:00am Monday – Thursday. Data was gathered on every single day of the course.

Data Analysis and Procedures

I went though and coded all of the data gathered from my daily log, the students' daily journals, the pre and post questionnaires, and the observation notes provided by Ms. Lenzlinger. After all data was coded and analyzed, I determined there were three specific factors I wanted to focus on; if the curriculum was fun and engaging, if the curriculum was educational and inspired learning, and if the curriculum allowed for students to think about future implications such as courses and careers.

A fun and engaging curriculum is important to keep kids engaged and inspire them to continue perusing computer related activities. Next, I wanted to see if what the students were doing really was teaching them about programming, how to program, and the importance of learning programming. Finally, my goal was to inspire students to think about their own futures and how they can have careers in the STEM fields. All of my data was coded, and then re-coded to focus on these three factors.

Validity and Reliability

The results from this research are specific to teaching a small section of students for a short period of time. Data was based on student feedback and my observations. It was triangulated by the observation of a co-worker. I am confident that these findings are valid, reliable, and would accurately pertain to a much larger population of students.

Findings

Fun/Engaging/Inspiring

As stated, the goal of this research was to find out what lessons and activities will inspire students to become more interested and engaged in computer programming. In order to engage and maintain the interests of middle school students, the curriculum needs to be fun and energizing. The students began with Code.org because of how fun and kid focused it is. Students learn the concepts and logic of computer programming-by-programming known characters such as the Angry Birds and Plants vs. Zombies to move around the screen and solve increasingly difficult problems. Certain stages incorporated a fair amount of math, particularly geometry shapes, angles, and division. As students work through the various stages, they earn trophies and finish the program when they have gained all 27 trophies. As mentioned before, between every few stages there are short, contemporary videos featuring famous people.

Every day I noted in my journal how focused and engaged the students were. Each morning they would come into the classroom, log on and be working on the Code.org level they left off on before class even officially began. Not only were they completely engaged, they seemed genuinely engaged in it. This observation was confirmed by Ms. Lenzlinger's observations when she wrote, "It seems like every student is really enjoying what they are working on." She went on to state, "That's really great that they get to use Angry Birds to learn the computer concepts."

As a result of how enjoyable Code.org was students really made it a priority to complete it, regardless of how long it took. Some students who had started it in a previous class finished on day 1. It took the boy from Gambia the longest, finishing Code.org on day 6. Girl A wrote in her journal entry for day 4, "Today I am still on code.org and I am getting close to being done with it and my goal is to get it done by Monday." Upon completing Code.org students received a printed out certificate signed by Code.org's founder Hadi Partovi. I found this small token of accomplishment further engaged the students. I noted in my journal how excited Girl A seemed on day 5 when she finished and I presented her with her certificate.

After completing Code.org, students then moved on to learning the programming language HTML through the lessons on the Web site CodeCademy. CodeCademy is a Web site with tutorials in many programming languages geared towards young people. Students are engaged, then rewarded, by earning badges as they complete sets of lessons within each course. Boy B wrote on day 3, "Today I accomplished a lot I got 3 new badges on codeacademy it was very fun [sic]." Girl B concluded her day 3 journal entry by writing, "HTML is super fun and I can't wait for tomorrow." On day 4, Boy E wrote, "This week I finished HTML and I got about halfway through CSS, and I had lots of fun learning about code!"

One of the things truly amazing and engaging with Code.org and CodeCademy is that they both offer their lessons in Spanish. As mentioned before, one boy, Boy A, was afraid to take the course because he was not very confident with his English skills. Had the sites not been available in Spanish, I am not sure what I would have done. Fortunately, Boy A was able to do the entire curriculum, which he finished on day 3. I noted how happy and engaged he seemed each day and was happy with myself that I was able to help him when he got stuck because of how versed I am with the Code.org curriculum. Boy A used Google Translate to fill out his journal each day and submitted on day 3, "code.org finished today and I learned to do many things with the commands." The offerings of the courses in Spanish are imperative to inspiring minority youth in STEM and computer programming.

Educational

The goal of providing a fun and engaging course was so that the students would indeed learn about programming, how to program and why it is important. Students learned how to program, and programming logic and languages by working through the Code.org and CodeCademy tutorials at their own pace each day. In addition, students had to watch a daily video or videos and write in their journal about what they viewed. On day 1 students watched two short videos, one of President Obama, the other of Vice President Biden, both speaking in favor of Code.org and teaching children about coding. Day 2 was a 10-minute video "Code Stars" made by Code.org. Boy B writes, "Response to Video: You should learn code because it is the closest thing to a superpower. It isn't hard, its really fun and you don't have to be a genius." Boy A, through Google Translation wrote, "Programming video (Code Stars) many people think that it is important that all people know some programming, I'm interested because I want programming that requires programming." Boy E added, "I agree that everyone should learn code." The video used famous people to communicate all the different things that can be made with code and jobs that include computer programming.

On days 3 and 6 students watched videos from the new Web site MadeWithCode. This Google owned Web site is geared towards inspiring girls to become interested in coding. It features short videos on different females in a host of professions. Girl C wrote, "I think that the Web site was really fun to look at and I thought that the girls who used code and dance together was a really interesting and it seemed like a lot of people were interested in it, I knew I was [sic]." Girl B wrote, "In MadeWithCode, people who were interviewed were talking about how they changed the world." One interesting thing I found was that none of the boys ever said this is a Web site for girls. Boy D wrote, "I learned that you can use code in many things such as dance, art, playing and a lot of other things." I think that MadeWithCode is a wonderful and vital resource for teaching and inspiring young girls to be interested and confident in code.

The students truly learned a lot during their two-week course. On day 7, after watching another Code.org video Girl A wrote, "The video was about kids learning coding and I think it is amazing that kids are learning code and now knowing more then their parents about computer science." On that same day Boy A, through Google Translation shared, "Today I learned more HTML code in some difficult but I really like learning about codes and programming."

The pre and post questionnaires also confirm that the students learned a lot during their two weeks. The questionnaires were completed as a likert scale from 1 (little to no knowledge) to 5 (knowing a lot). For Question 2 "I know a lot about computer programming" responses on the pre questionnaire resulted with only 3 of the 10 students giving themselves a 4 or 5 and 6 of the other 7 gave themselves a 1 or a 2 (see Figure 1). On the post questionnaire 6 students ranked themselves a 4 or 5 and none of the students game themselves a 1.

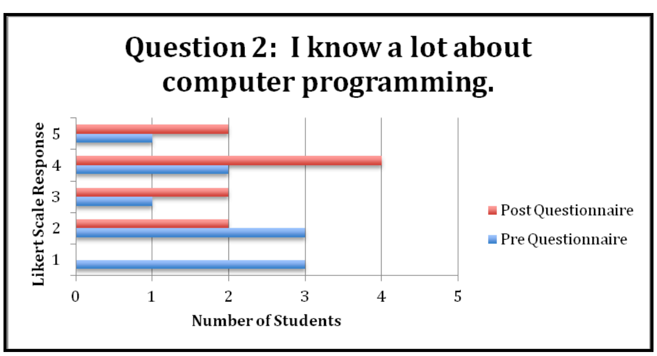

Figure 1. Question 2.

Question 4 asked the students to rate themselves using the same likert scale on the statement "It is important to know computer programming." The pre questionnaire yielded answers across the spectrum with only 4 students ranking it a 4 or 5. On the post questionnaire every student but 1 ranked it a 5 and the last ranking was a 3 (see Figure 2).

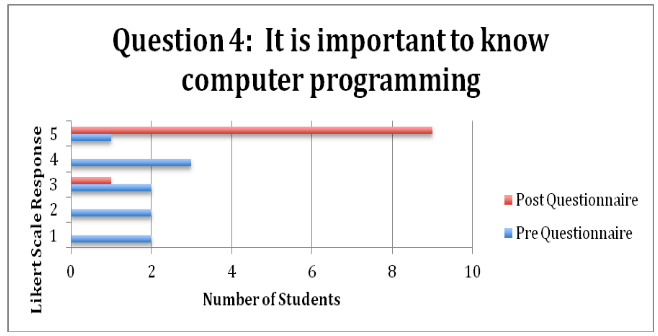

Figure 2. Question 4.

Question 8 asked, "I know what the different computer languages are and how they are used like HTML, CSS, and JavaScript." In the pre questionnaire 6 out of 10 students put 1 (they know nothing), another two students put 2, and no students put 5. On the post questionnaire no students put a 1 and only 2 students put a 2, leaving 8 of 10 students ranking a 3, 4, or 5 showing they clearly felt they learned some of the different programming languages (see Figure 3).

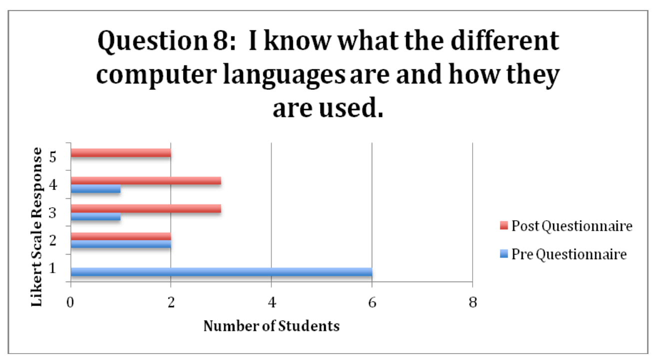

Figure 3. Question 8.

Finally, to attest to learning, the questionnaire asked a fill in the blank "What is computer programming?" 4 responses in the pre questionnaire were along the lines of "I don't know" and only 2 answers communicated a sound understanding. In assessing the answers from the post questionnaire, I've concluded that all students had a basic to firm understanding of computer programming (except the boy from Gambia who did not fill in the question.) Responses include, "It is a writing languages for the computer so that the computer does stuff that you write." And, "It is programming things what to do such as apps, games and robots." Girl A wrote in her journal on the final day, "I didn't know that coding was so important and I didn't know it could be so much fun! I loved doing this class and I hope to learn more soon."

Focus on the Future

The final goal and factor of this research was to see what in the curriculum would inspire the students to think about their futures. The daily supplemental videos did exactly that. On day 2, in response to "Code Stars" Girl A wrote, "The first video talked about how only 1/10 kids are learning coding. There were people saying that they learned it from age 7 to now. That is a lot of practice. From that, one person made Facebook, and other made Twitter. Even rock stars need code, to work all the lights and sounds." On day 4, in response to the video "12 Year Old Prodigy Dreams in Code," Girl B wrote in her journal, "I watched a video about a genius kid who is 16 and has made 9 games. I want to be like him. I want some MoNeY!"

From the questionnaire, question 6 asked, "I am interested in having a job someday that involves computer programming." From the pre questionnaire, six students had an answer of 1-3 (not interested, to kind of interested). In the post questionnaire, no students put a 1, two students put a 2, two students put a 3, and 6 of the 10 students put a 4 or 5 (see Figure 4).

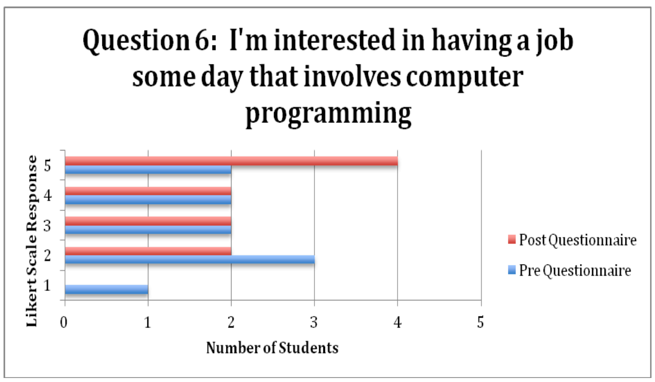

Figure 4. Question 6.

For the written response question, "What jobs can you have if you know how to program?" The pre questionnaire yielded 4 answers of "I don't know" or "not sure." The post questionnaire had ideas from everyone including, "You can program Web sites, design animation films, and video games." Boy A wrote, "You can catch cyber theft." Girl C added, "Almost every job includes some aspect of programming."

Discussion

It seems clear that with the right curriculum all students, including and especially females and minorities, can learn computer programming and be inspired to consider having a career in the STEM fields. Thanks to Web sites such as Code.org, MadeWithCode, and CodeCademy, students can learn about computer programming through fun and engaging sites and be inspired to think about their future. Indeed, as was noted in the Journal of STEM Education writing about the program SPIRIT, "It is encouraging that a two-week program…resulted in a statistically significant positive change in attitudes for female students (Forssen, et al, 2011, p. 47".

One of the important aspects about my course was that students were able to work at their own pace. It was very individualized for each learner. I laid out a sequence of activities that went in a particular order and built on the previously learned lessons. In this way students could feel confident while they worked and never feel rushed or frustrated. As a result of this approach, all students learned the basic programming logic. Most of the students learned the basics of HTML and a few began learning in JavaScript. Every student felt accomplished and enjoyed being able to work at his or her own speed.

Media also seems to play an important role. Short, modern videos with graphics and which state of the art technology really captured the attention of the students while they watched individually at their computer with headphones. I also allowed them to watch the videos whenever they wanted to during the day. Some watched right away, others waited until towards the end of class. Giving them this choice allowed them to take more ownership in their learning. They enjoyed watching them because they had the freedom to choose when it happened and listen with their own headphones. As a result they gained a lot of knowledge about STEM careers and the importance of computer programming.

Conclusion

Computer programming and STEM education is the future. The world is increasingly run by and dependent on technology. Understanding the STEM disciplines and knowing how to code and program are the factors that will decide who gets the good jobs and who does not. Further, countries that do not teach their children these skills will quickly fall behind in the world. It is imperative for the United States to teach all children, beginning at a young age, how to code and program. Students such as girls and minorities that historically do not enter these professions especially need to learn coding and programming.

The middle school level is the perfect age to begin inspiring and educating students in the STEM and coding fields. Students this age are old enough to read instructions and guide themselves through tutorials, and young enough to be molded and energized. Fortunately there are now a plethora of resources that can be utilized to engage all students in computer science.

I would encourage any teacher looking to teach coding to follow the approach I used. Creating an ordered sequence of the free tutorials online and facilitating the class through it with each student working at their own individual pace. Teachers need to be versed in the entire sequence so that they can move around helping students at all different stages. Using supplemental media is also key in inspiring students and breaking up their work time.

My only regret is not doing more in-class collaborating. It is important for students to share what they have learned and made and to have dialogue with each other. Because of the rushed nature of this course the collaboration did not happen. Next time I would use a blog format in conjunction with the journal to encourage communication.

Code.org, CodeCademy, and MadeWithCode are truly remarkable resources. Not only do they teach youth the many different computer languages with tutorials in multiple linguistic languages, they are also extremely literacy based. There is a lot of reading and comprehension taking place. These free resources and the best tools for teaching middle school students about coding and programming. They are hip, engaging, informative, and rewarding. I look forward to inspiring more students with these resources and seeing a generation of *all* students join the world of STEM.

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Acknowledgements

Dr. Annette Hemmings, for teaching me how to conduct an action research project and assisting me in gaining my Master's degree. Francis Johnson, for being the best education advisor. Principal David Jennings, for hiring me at Badger Ridge Middle School and making this all possible. Thanks also to Liz Dannenbaum, Michael Cohen, and Briana Lenzlinger for their help and dedication.

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Appendix A

Pre/Post Questionnaire (Google Form)

Computer Programming Questionnaire

Complete this form about yourself. Choose 1 for low or no. Choose 3 for middle or kind of. Choose 5 for yes or strong

* Required

I enjoy using computers *

1 2 3 4 5

no, not at all ◯ ◯ ◯ ◯ ◯ yes, all the time

I know a lot about computer programming *

1 2 3 4 5

no, not at all ◯ ◯ ◯ ◯ ◯ yes, I can program in different languages

I have a lot of experience programming computers *

1 2 3 4 5

no experience ◯ ◯ ◯ ◯ ◯ tons of experience

It is important to know computer programming *

1 2 3 4 5

not at all important ◯ ◯ ◯ ◯ ◯ extremely important

I am interested in having a job someday that involves computer programming *

1 2 3 4 5

no, not at all ◯ ◯ ◯ ◯ ◯ yes, my job must include programming

I have the ability to work in a profession that uses computer programming *

1 2 3 4 5

no, I am not able to have a job with any programming ◯ ◯ ◯ ◯ ◯ yes, I am completely able

I know what the different computer languages are and how they are used like HTML, CSS, and JavaScript *

1 2 3 4 5

I have no idea ◯ ◯ ◯ ◯ ◯ I know all of them and how they work

What is computer programming? *

☐

What jobs can you have if you know how to program? *

☐

What are some computer programming skills you still need to improve? *

☐

☐ Send me a copy of my responses.

Submit

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Appendix B

Blank Journal given to students on day 1

My Computer Programming Journal

What did I do, learn, enjoy?
What did I find interesting?
What questions do I have?

Please write in journal through each day. The more detail and info the better!

Date:

Journal Entry:

Date:

Journal Entry:

Date:

Journal Entry:

Date:

Journal Entry:

Appendix C

Daily Video Guide and links

Introduction to Computer Programming
Video Guide
Summer Enrichment 2014

Day 1
* Vice President Joe Biden supporting Code.org
https://www.youtube.com/watch?v=aaYk_nt4kVo
* President Barack Obama supporting Code.org
https://www.youtube.com/watch?v=6XvmhE1J9PY&list=PLzdnOPI1iJNe1WmdkMG-Ca8cLQpdEAL7Q

Day 2
* "Code Stars" by code.org
https://www.youtube.com/watch?v=dU1xS07N-FA

Day 3
* MadeWithCode intro video on homepage
https://www.madewithcode.com/
* All 6 videos in MadeWithCode - Mentor section
https://www.madewithcode.com/mentors

Day 4
* "14 Year Old Prodigy Programmer Dreams in Code" by THNKR
https://www.youtube.com/watch?v=DBXZWB_dNsw

Day 5
* "The Latest News: Computer Coding for Kids" CNN
https://www.youtube.com/watch?v=ZzmAw0dVMv8
* "Cracking the Code: A Push to Teach Computer Science in Classrooms" CBS
https://www.youtube.com/watch?v=sUXfjzzHO5g&index=7&list=PLzdnOPI1iJNe1WmdkMG-Ca8cLQpdEAL7Q

Day 6
* All 5 videos in the MadeWithCode - Maker section
https://www.madewithcode.com/makers

Day 7
* "Is Code the Most Important Language in the World" PBS
https://www.youtube.com/watch?v=Vxv0-sggnqA

Day 8
"What Most School Don't Teach You" Code.org
https://www.youtube.com/watch?v=Vxv0-sggnqA