COMPUTER SCIENCE EDUCATION: ONLINE CONTENT MODULES AND PROFESSIONAL DEVELOPMENT FOR SECONDARY TEACHERS IN WEST TENNESSEE – A CASE STUDY

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ABSTRACT

With ongoing efforts in the United States to further develop the availability of computer science education in the public schools, federal, state, and local educational agencies are increasing efforts to encourage and promote the inclusion of computer science and programming skills in the middle school curriculum (Grover, Pea, & Cooper, 2015). The goal for the Online Content Modules: Computer Science in the Middle Grades project was the development of five online content modules with a focus on computer science instruction in three public school districts in West Tennessee, and disseminated through a week-long professional development summer institute.

Keywords: Online Learning, STEM, Computer Science, Coding, Secondary Education, Teacher Professional Development.

INTRODUCTION

Far too often, the "T" in STEM (Science, Technology, Engineering, and Math) education is provided only nominal support via the use of the latest technologies available in classroom settings in searching for information via the Internet and using common productivity applications, such as word processing, spreadsheet creation, and presentation software (Howley et al., 2011). In recent years, increasing interest and effort has been dedicated to introducing computer programming, often referred to as "coding", to students in K-12 settings, especially at the middle and high school level (Settle et al., 2012; Richtel, 2014). While computer education in the upper secondary grades (10-12) is becoming more prevalent where additional instructional resources are available, the middle secondary grades (6-9) have lagged somewhat in introducing computer science to younger students (Grover et al., 2014). However, several recent studies have provided evidence that introducing computer science and programming skills at the middle school level can help pave the way for students' future educational and even career goals (Roschelle et al., 2010; Rodger et al., 2012; Taub et al., 2012; Woolley et al., 2013; Grover et al., 2015).

In June 2016, President Obama announced the start of an educational initiative, Computer Science For All, whose stated purpose is to "empower all American students from kindergarten through high school to learn computer science… both educators and business leaders are increasingly recognizing that Computer Science (CS) is a 'new basic' skill necessary for economic opportunity and social mobility" (Whitehouse.gov, 2016). With a national effort to further the availability of computer science education, state and local educational agencies are increasing efforts in disseminating the inclusion of computer science and programming skills in the K-12 school curriculum (Cheung & Slavin, 2013). Such efforts are based, in part, on the documented successes in integrating game-based programming and coding in STEM-based coursework for middle and high school students (Repenning et al., 2010; Werner et al., 2012; Burke, 2012; Brown et al., 2013).

Due to the increasing emphasis and acknowledgment of the importance of introducing computer science education in the secondary school grades, the goal and focus of the Online STEM Content Modules: Computer Science in the Middle Grades project was to enhance computer science content taught in the Middle School (grades 6-8) Science, Technology, Engineering, and Mathematics (STEM) curriculum.

While the current Middle School Career and Technology Education Coursework provided by the Tennessee Department of Education (2016) does not specifically identify Computer Science or computer programming/ coding, aspects of computer science instruction are embedded in the Computer Applications and, to a certain degree, the STEM Designers coursework.

The STEM Designers course (the third course in the Middle School STEM sequence of Coursework) description cites the P21: Partnership for 21st Century Skills Framework for 21st Century Learning (2009); the P21 Framework was developed as an ongoing collaborative effort "with input from teachers, education experts, and business leaders to define and illustrate the skills and knowledge students need to succeed in work, life, and citizenship, as well as the support systems necessary for 21st century learning outcomes" (ibid.). The P21 Framework aspires to represent "both 21st century student outcomes... and support systems" (ibid.). Regarding computer education, the P21 Framework addresses several facets of desirable student proficiency achievement within the 21st Century Student Outcomes (P21, 2009).

1. The Study

The primary goal of the Online Content Modules: Computer Science in the Middle Grades project was the development of five online content modules with a focus on computer science instruction in middle schools. These online modules were developed with the direct input of five identified expert secondary computer science teachers employed in and identified by two of the partner county school districts, plus one each from two municipal school systems. The development team met from January to May 2017 on one Saturday each month at the University of Memphis' campus in Jackson, Tennessee (TN) for a total of five face-to-face meetings. Other activities and communications took place online via email and uploads to a mutually accessible web-based repository. The development team was also responsible for instruction using the online computer science modules during teacher professional development workshops.

Upon completion of the online Middle School Computer Science (MSCS) content modules, a program of workshops was provided for all secondary STEM and STEM related teachers identified by and recruited from-partnering school districts were conducted at the University of Memphis' campus located in Jackson, TN from in June 2017. The summer institute workshops introduced the online MSCS content modules to all teacher/participants representing the three partner school districts and provided examples of how these can be integrated to enhance existing or new STEM and/or computer science classes offered in the partnering district middle and high schools. Forty-three teacher participants attended the five-day workshop, with instruction based on the online modules provided by the five teachers who comprised the modules' development team.

Also, during the five-day summer institute workshop guest speakers representing leadership in the partner school districts, the TN Department of Transportation, the TN STEM Innovation Network (TSIN), the National Youth Cyber Education Program, the Robotics Education & Competition (REC) Foundation, and the West Tennessee STEM Hub provided informative presentations and demonstrations on various topics associated with STEM education throughout the state.

In recruiting teachers/participants from the partnering school districts, leadership for the three partner school districts were asked to provide email contact information for all secondary STEM and STEM-related (science, math, career, and technology education) teachers from their school districts. The project director communicated with the teachers by emailing the information regarding the opportunity to participate in the June workshops and the compensation provided for participation. Of those who were contacted, 57 total responses were received; of those, 43 teachers participated in the summer institute.

The 43 teachers participating in the summer institute professional development workshops were administered pre-institute and post-institute assessments regarding their knowledge, skills, and attitudes towards computer science instruction in the classroom. A survey was developed to measure attitudes towards computer programming and computer science in general; this instrument was derived from the Fennema-Sherman mathematics attitudes scales (Fennema & Sherman, 1976), modified to reflect programming and computer science rather than mathematics. The survey consisted of 49 pre and post professional development questions requiring corresponding positive and negative statements to a Likert-type scale with 1 indicating they strongly agreed to a 5 indicating that they strongly disagreed with the statement. The survey consists of five subgroups, with several items in each category required interpreting the data in reverse, as they were written as negative items. The negative statements are reverse coded prior to summing the subscale scores. The survey uses five of the seven subscale categories used in the Fennema-Sherman instrument and, in addition, the survey starts with a statement concerning the participant's intent to teach computer science. The reliability of the instrument was evaluated for internal consistency of the subscales (Williams et al., 2002). The final results are displayed in Table 1; a line graph to depict positive mean score changes for all categories is shown in Figure 1.

Sub-Scales	Survey Statement Numbers	Pre	Post
Attitude toward success in teaching computer science	2-13	2.41	1.69
Computer science as a male domain	14-21	1.76	1.34
Usefulness of computer science and programming	22-29	2.70	2.22
Confidence in learning computer science and programming	30-39	2.75	2.45
Effective motivation in computer science and programming	40-50	2.88	2.47
Overall		2.50	2.03

Table 1. Pre and Post Computer Science Teacher Attitude Survey

In addition, a follow-up survey assessing classroom use of the computer science knowledge and skills acquired during the Summer Institute work sessions was distributed to the participant teachers to determine if, when, and how the online computer science modules' content was being taught in their classrooms. The online survey was made available to participants in October 2017; 29 of the 43 total participants responded to the second survey. Key results for the questions below from the follow-up survey are shown in Figures 2 through 7.

Question 1: The Computer Science summer institute professional development activities enhanced my understanding of computer science & programming.

Question 2: The Computer Science summer institute professional development activities enhanced my overall interest in computer science.

Question 3: The Computer Science summer institute professional development activities increased my

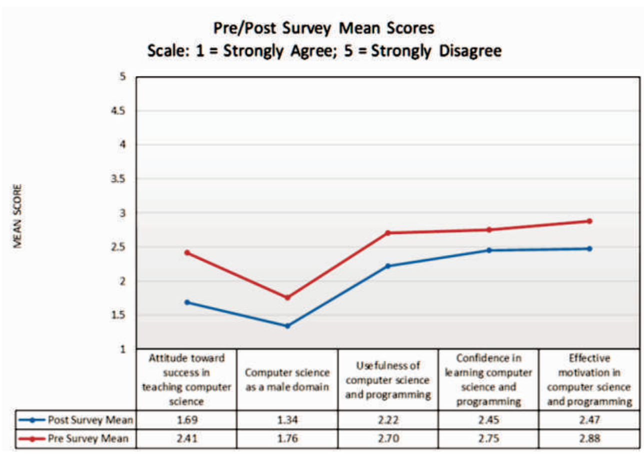

Figure 1. Pre and Post Computer Science Teacher Attitude Survey Chart: Mean Scores

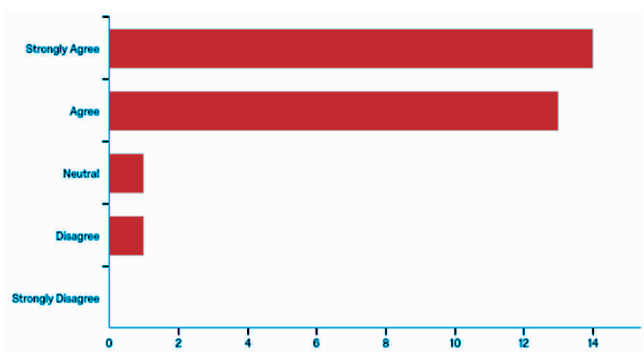

Figure 2. Bar Chart showing the Results of Question 1

awareness of different computer science applications in the professional world.

Question 4: The Computer Science summer institute programming activities this summer were helpful and are useful in my teaching this Fall.

Question 5: I integrate and use the Computer Science content modules available via BFK/TN and Summer Institute professional development activities in my teaching this Fall.

Question 6: The online Computer Science content modules are more helpful than traditional textbooks to assist in my teaching Computer Science or other STEM-related topics.

2. Findings

The purpose of the summer institute professional development pre and post survey was to measure if and how the participant teachers' attitudes towards computer science as an instructional as well as professional content area might have changed due to the use of the online computer science modules, in addition to exposure to other computer science content of the five-day summer

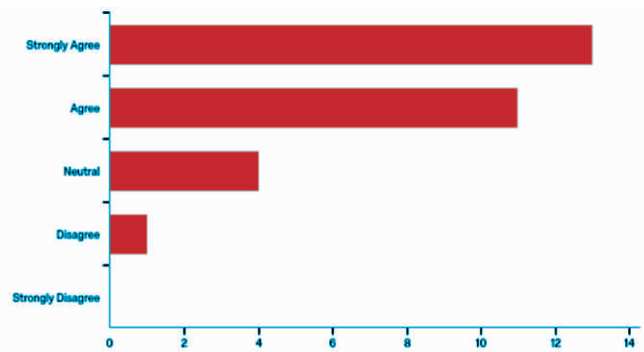

Figure 3. Bar Chart showing the Results of Question 2

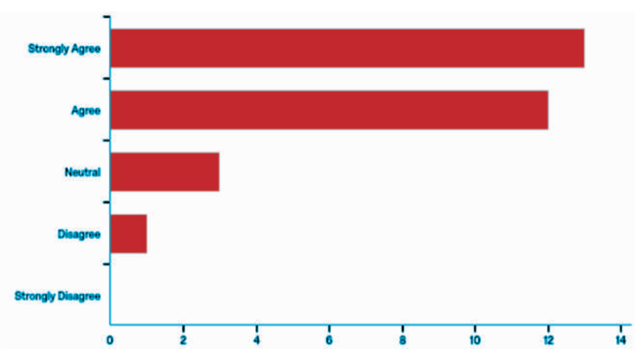

Figure 4. Bar Chart showing the Results of Question 3

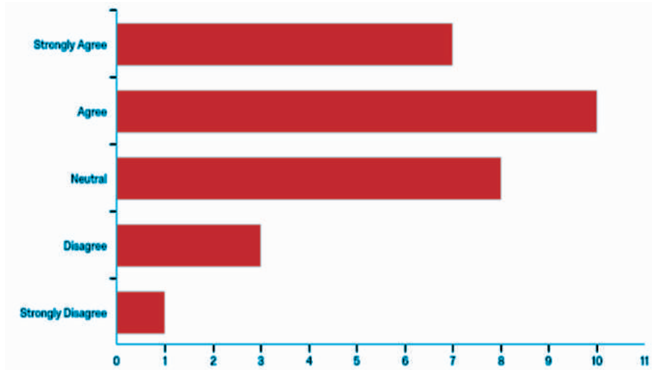

Figure 5. Bar Chart showing the Results of Question 4

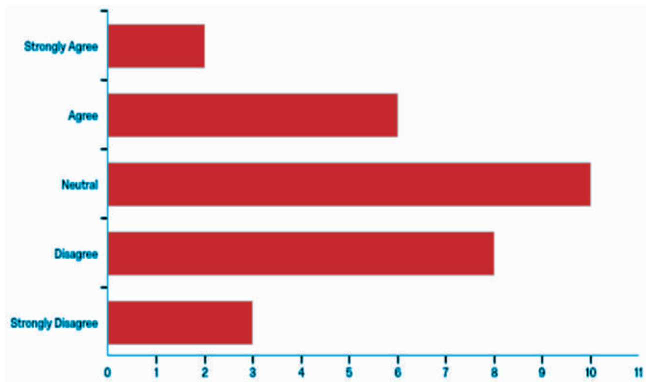

Figure 6. Bar Chart showing the Results of Question 5

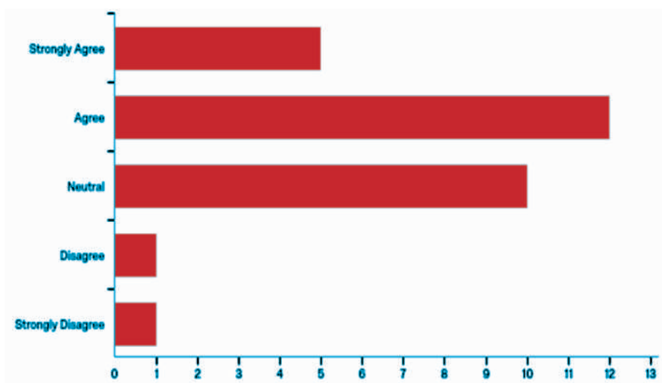

Figure 7. Bar Chart showing the Results of Question 6

institute. As can be viewed in Table 1, the difference between attributional positive attitudes towards computer science pre and post workshop responses overall was relatively small: Pre: 2.50 and Post: 2.03, or a .47 difference towards a more positive attitude after the week-long institute.

Though still relatively minute, the most statistically significant increase in positive responsiveness was regarding the survey's sub-scale regarding the teachers'

"Attitude toward success in teaching computer science"; the increase in average positive attitude from 2.41 to 1.69 (from Agree and Neutral, to Strongly Agree or Agree) was .72 points.

The most notable difference to the researcher was the slight gain in positive attitude (.42) towards "Computer science as a male domain", from 1.76 to 1.34. This indicated that the responding teachers increased their perception that computer science as a profession or educational subject was predominantly a male-oriented area.

The follow-up survey was distributed to the 43 participants during the Fall semester was designed to assess the subsequent classroom use of the computer science knowledge and skills acquired during the summer institute work sessions. The survey was intended to also determine if, when, and how the online computer science modules were being used in the participants' classrooms. The online survey was made available to participants in October 2017; 29 of the 43 total participants responded to the second survey. The key results from the survey (as shown in Figures 2 through 7) indicated the following:

In response to Question 1, "The Computer Science summer institute professional development activities enhanced my understanding of computer science & programming", 27 of the 29 respondents (93%) strongly agreed or agreed with that statement.

In response to Question2, "The Computer Science summer institute professional development activities enhanced my overall interest in computer science", 24 of 29 respondents (83%) strongly agreed or agreed with that statement.

Responding to Question 3, "The Computer Science summer institute professional development activities increased my awareness of different computer science applications in the professional world", 25 respondents (86%) strongly agreed or agreed with the statement.

In response to Question 4, "The Computer Science summer institute programming activities this summer were helpful and are useful in my teaching this fall", 17 of the 29 respondents (59%) indicated that they strongly agreed or agreed with the statement.

Responding to the statement provided in Question 5, "I integrate and use the Computer Science content modules available via BFK/TN and summer institute professional development activities in my teaching this Fall", eight of the respondents (28%) agreed or strongly agreed, while 18 (62%) were neutral or disagreed with the statement.

In responding to the statement in Question 6, "The online Computer Science content modules are more helpful than traditional textbooks to assist in my teaching Computer Science or other STEM-related topics", 17 respondents (59%) indicated that they agreed or strongly agreed with the statement, however ten (35%) provided neutral responses.

Conclusions

The summer institute professional development pre- and post survey was used to measure if and how the participant teachers' attitudes towards computer science may have changed due to the use of the online modules and exposure to other computer science content during the five-day professional development sessions. While differences were statistically insignificant overall, the most surprising difference to the researcher was the slight gain in positive attitude (.42) towards "Computer science as a male domain", from 1.76 to 1.34. This indicated that the responding teachers, after five days of exposure to several women instructors and presenters specializing in coding, robotics, and other STEM related contents, increased their perception that computer science as a profession or educational subject was predominantly male-oriented. While it is not possible to determine from the survey alone, as 80% of the responding teachers were women, there is a possibility that the rural and semi-rural and thus more traditional countries that comprised their workplaces and homes could posit an influence on attitudes regarding male and female roles in the workplace and school environments. Because the pre and post surveys were distributed after only a five-day professional development institute, a long-term study with participants with similar demographic backgrounds could prove interesting as a future study. However, as has been noted in previous research studies (Broos, 2005; Carter, 2006; Cohoon & Aspray, 2006; Moss-Racusin et al., 2012), mathematics, science, and computer science - in particular - have frequently been viewed by teachers and students alike as a primarily male-oriented and, subsequently, a male-dominated domain.

The results of the Fall semester follow-up survey, with 29 of the 43 participants responding to the statements assessing their use of the computer science modules and knowledge and skills acquired during the summer institute in their own classrooms, indicated that the participants were mostly satisfied with the content they were provided. However, somewhat unsurprisingly, a majority of the respondents also indicated that they were not using the online computer science content modules in their classrooms, and many were neutral, or uncommitted, in finding the modules to be more useful than traditional textbooks in their classrooms.

A component of this study that was not reported here – however important to include in this discussion - consisted of phone interviews with three teacher/participants in the summer institute. This qualitative data provided a possible glimpse into why at least some teachers in one of the districts represented (the largest) may not be using the online modules. All three interviewees indicated that the content they were allowed to present in their classrooms was tightly controlled and restricted by their districts and administrators, and the content taught must reflect the district-mandated curriculum as established and required by the TN State Department of Education.

The irony of this last finding is that the study being discussed here was funded by the United States' Department of Education via the Tennessee Higher Education Commission (THEC), in an ongoing effort to stimulate educational innovation and resources to improve students' understanding of STEM and STEM-related content in general, and, in this project's example, computer science in particular. As per Harris et al. (2009), teachers' use of educational technologies "are limited in breadth, variety, and depth, and are not well integrated into curriculum-basedteaching and learning" (p. 393). When teachers are exposed to innovative, alternative instructional resources – funded at the federal and state level - but subsequently not allowed to incorporate these in their classrooms, the question as to the ultimate purpose of these projects remains.

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