Preparing Elementary Pre-Service Teachers to Integrate Computing across the Curriculum (PEPTICC) Seminar:

An Evaluation Report

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Executive Summary:

With the growing recognition of computational thinking as basic literacy today, the integration of computational thinking within primary and secondary level school curriculum is gaining worldwide traction. Although in its infancy, programming education is becoming increasingly ubiquitous as educational institutions prioritize and streamline their focus on cultivating computational thinking amongst children and programming education. As such, University of South Alabama is implementing PEPTICC (Preparing Elementary Pre-Service Teachers to Integrate Computing across the Curriculum) Seminar to train preservice teachers on computational thinking concepts and its integration within the K-6 curriculum. The report presents experiences and perceptions of PEPTICC seminar participants regarding its efficacy in equipping preservice teachers with needed computational skills for an integration as such. The findings point to improvement in participants' knowledge and skill level post training whereby participants mention feeling somewhat confident navigating computational thinking. The participants however cite the need for more practice to gain fluency with educational robots and implement and integrate the concepts within K-6 teaching. The study recommends increasing training hours, giving students more time to tinker with the robots, as well as assigning students with extra credit or grades for their participation in the seminar to increase their motivation levels. Furthermore, the report points to areas of improvement within PEPTICC seminar content and structure by incorporating sample lessons and teaching demonstrations showcasing meaningful integration of computational thinking and K-6 teaching for participants.

Background

As a part of the National Science Foundation (NSF) grant, the department of Electrical and Computer engineering and Counseling and Instructional Sciences at the University of South Alabama are jointly implementing a training seminar called ‘Preparing Elementary Pre-Service Teachers to Integrate Computing across the Curriculum (PEPTICC)’. As such, the seminar is training five cohorts of K-6 preservice teachers (PST) on integrating computing in K-6 subject teaching. The preservice teachers are trained on computing concepts such as computational and algorithmic thinking and its integration within K-6 English, Social Studies, Math, and Science curriculum.

Objective:

As the project seminar is training teachers on new concepts associated with computational thinking, it is important to gauge the effectiveness of the training program. This evaluation aims to examine the immediate output from the training and determine its effectiveness. As such, the evaluation assesses the uptake from training seminars and its role in building preservice teachers’ proficiency in computational thinking skills and their ability to integrate it within K-6 curriculum.

Logic Model:

The logical framework for this project outlines the existing gap within the K-6 school curriculum in incorporating computer science and algorithmic processes within children’s educational curriculum. As such, the priority of this project is to build the capacity of pre-k service teachers in incorporating and integrating fundamental concepts of computational thinking within the existing school curriculum. The project aims to achieve this by training preservice teachers on how to use STEM robots such as mTiny and mBot Neo to create lesson plans that incorporate and encourage computational thinking with English, Science, Mathematics, and Social Studies curriculum. While the immediate output of this project is the total number of teachers trained and seminars held, the long-term outcome of this project is aimed at building foundational computational skills of K-6 students. Preservice teachers and PEPTIC project team members at the University of South Alabama are the primary stakeholders of this project.

Program Theory:

If Pre-K Service teachers are trained and equipped with skills needed to integrate computational thinking concepts across school curriculum, students become competent in computational and digital literacy skills and will have improved problem solving, communication, and creativity skills.

Assumptions:

- There is buy-in from pre-service schools, teachers, and concerned stakeholders in integrating computational thinking components across the curriculum.
- Preservice teachers are interested in learning about computational thinking and integrating those concepts into their teaching curriculum.
- Available funding resources for training seminars.
- Students will understand and apply the basic concepts of computational thinking in their classes.

Program Logic Model
Preservice teachers training on integrating computational thinking across the curriculum (PEPTIC)

Situation (Gaps and Priorities	**Inputs (what we invest in the program**	**Outputs: Activities**	**Outcomes (Impact) Short Term Results**	**Outcomes (Impact) Medium Term Results**	**Outcomes (Impact) Long Term Results**
Gaps: - Lack of lessons on Computational Thinking and Algorithmic Processes within K-6 curriculum **Priorities:** - Build proficiency of preservice teachers on Computational Thinking and its successful integration within K-6 curriculum - Build the capacity of Pre-k service children on computational thinking, coding, and programming using mTiny and mBlock robots	**Resources:** Provide pre-service teachers with mTiny and mBot Neo Robots Training seminars on Computational Thinking, and its integration within in Math, Science, English, and Social Science curriculum Job-Aids, Powerpoints, training content, sample lesson plans (integration computational thinking elements) and materials for participants Funding, Technology, Trainers, Facilitators, Planning Meetings	Number of preservice teachers trained on computational thinking integration across curriculum Number of PEPTIC training seminars held	Pre-K Service teachers are proficient in the concepts of computational thinking, programming Data shows growth in integration of computational thinking elements across K-6 teaching. (A program evaluation would assess the uptake from training seminars and its integration within K-6 teaching)	K-6 students have improved digital literacy, understand algorithmic processes, acquire and apply basic programming skills. (A program evaluation would measure the immediate impact of integrating computational thinking within school teaching on students' programming skills via assessments, observation, and interviews)	K-6 students have foundational skills in computational thinking and improved problem-solving, logical reasoning, mathematics, and communication skills. K-6 students are well-equipped to pursue STEM degrees including Computer Science. (An impact assessment of PEPTIC Seminar would look into long-term impacts of implementing integrated curriculum on students and their overall academic performance and potential for pursuing a STEM degree)

Problem Statement

Majority of the elementary preservice teachers do not have a background in computing and are not familiar with the concepts of programming, coding, and algorithmic thinking. Computing in this project means "the study of computers and algorithmic processes". Based on the Alabama State Standards and CSTA K-12 Computer Science standards 1A and 1B, the following topics have been included in this project: hardware and software, network and the Internet, data and analysis, algorithms and programming, impact on society, and design thinking.

Research Questions:

- How effective is the PEPTICC program seminar in equipping elementary preservice teachers with skills on computational thinking?
- Are they able to integrate computing within K-6 subject teaching?
- Is the seminar content and timeframe adequate to meet the learning needs of elementary preservice teachers?

Literature Review

As with any other field, education in the last two decades has witnessed major changes and strides, especially with the growing use and integration of ICT (Information, Communication, Technology) tools and mechanisms. One such growing trend is the use of robotics to teach elementary school children computational thinking skills. Computational thinking now is regarded as one of the critical skill sets required for the new generation of learners (Munn, 2021). Munn (2021) explores the use of robots and robotics in teaching and enhancing computational thinking skills among sixth-grade school students. The sixth-grade students use robotics within their science and mathematics curriculum and engage in hands-on application learning activities. The activities facilitate computational thinking and engage students in key computational concepts such as abstraction, pattern recognition, decomposition, algorithm. Moreover, the hands-on application also facilitates collaboration, communication, teamwork, and problem-solving skills among students as they engage in teamwork.

While many schools worldwide are jumping on the computer science bandwagon, there isn't a standard model for integrating computer science (CS) and robotics within school curricula. El-Hamamsy et al. (2021) present a CS and Robotics integration model which has been validated through a pilot study in Switzerland. The pilot study which consisted of 350 primary school teachers went through a CS continuing professional development program (CPD) which included Robotics Unplugged activities and CS concepts. The teachers' assessment of the program was largely positive indicating replicability and generalizability of the model.

With the wide adoption of computer science and computational thinking within K-12 education, there are many challenges to introducing and retaining CS as a regular K-12 subject. Knobelsdorf and Vahrenhold (2013) in their article bring some of those concerns and challenges ranging from pedagogy, curriculum design, instruction, teacher training, diversity of students, including varied levels of cognitive abilities to the fore. The findings from this article on teacher training, curriculum design, and instructional method for CS teaching in K-12 subjects resonates with and thus is beneficial for PEPTICC project.

Evaluation Model

Kirkpatrick's model lies within the postpositivist paradigm which concerns itself with 'true experiments' where random selection and assignment to interventions is prioritized. While post positivist approaches predominantly focus on quantitative designs, it also uses mixed methods to evaluate programs (Mertens & Wilson, 2019). Kirkpatrick's model of evaluation is widely relied upon for evaluating training programs. It follows four stages of evaluation whereby it sequentially evaluates Reaction, Learning, Behavior, and Results from the training program (Mertens & Wilson, 2019, p. 78). In the first stage, participants' reaction to any given training is measured. Reaction here could be positive, negative, or neutral. This can be done using post training surveys, asking for feedback, observation, interviewing participants etc. In the second stage, Kirkpatrick's model gauges participant's learning from the training. What new knowledge and skills were the participants able to learn and retain during the training is measured in this stage. The third stage studies the changes at behavioral level and assesses the transfer of newly learned skills into practice and behaviors. Lastly, the fourth stage attempts to capture the outcomes and results that can be traced back to the training. Given the nature and scope of the PEPTICC Seminar, Kirkpatrick's model was chosen to guide the evaluation process.

Kirkpatrick's model of Evaluation	
Reaction Stage	Using a posttest survey, participants were asked to state their reaction to the training program, content, structure, what worked, what did not work etc.
Learning Stage	Participants' knowledge of computational thinking, skills in assembling STEM robots, and programming was evaluated
Behavior Stage	Participants' ability to integrate elements of computational thinking within the Pre-K to 6 grade curriculum and teaching was evaluated
Results Stage	Effects and outcomes from the training program such as integration of computational thinking and improved algorithmic thinking skills amongst children will be measured (for impact assessment to be carried out in later stages of evaluation)

Methods

Pre-Post Test Survey:

Pre and Post-Test surveys were used to gauge participants’ knowledge on computational thinking and document the changes in their knowledge levels post training seminar. The multi-dimensional survey comprised of 10 questions consisting of 5-point rating scale from strongly disagree to strongly agree as well as some yes/no questions. Altogether, n=10 respondents took the pre and posttest survey. The survey also recorded participants' experience and feedback on the seminar and documented what worked and what did not. It also asked about preservice teacher’s perception on the integration of computational thinking within school curriculum and its relevance for school children.

Interview Questions:

Interviews were conducted with few seminar participants (n=2). The interviews probed deeper into participants' experience and perception of the program, asking open-ended questions about the seminar such as what went well, what needed improvement, what needs to be changed. The interview questions also asked what they found relevant and important, what could the seminar do away with, and their expectation as well as confidence in the transferability of seminar content onto children’s curriculum etc.

Data Analysis:

The results from the surveys and interviews were computed and quantified with the help of Google Forms. The evaluator analyzed the findings and looked for outstanding issues, recurring themes, and patterns from the tests. Similarly, the results from qualitative data were transcribed, coded, and segmented. The findings from both quantitative and qualitative methods were integrated to construct a comprehensive understanding of participants' experiences and perception of the program as well as observed short- and long-term outcomes from the program.

Findings

Pretest:

The pretest questionnaire asked participants about their familiarity with computational thinking and algorithmic processes. The pretest also asked participants about their perceptions on integrating computational thinking within children's curriculum. A vast majority of the response showed that participants lacked familiarity when it came to computational thinking and coding. Given the participants are Pre-k service teachers whose academic background is in education, those participants have not had much interaction with STEM subjects. As such, the majority of the participants expressed feelings of anxiety and intimidation about the seminar's content and use of robots. There were few exceptions who were familiar with some of the fundamental computing concepts such as the use of loops, variables, algorithms, and conditional logic. Most of the seminar participants could not establish a direct connection when it came to integrating computational thinking within the school curriculum and children's mathematical, problem solving, logical thinking, and creativity skills. Participants however were positive towards such integration and deemed it relevant for students' growth and learning needs.

Posttest:

Some of the outstanding findings were that the participants were much more confident in their basic understanding of computational thinking concepts. The participants were also more likely to see how the principles and application of coding, algorithmic processing was applicable to student's thinking, problem solving, and creative skills. The participants were positive and willing about integrating computational thinking within their teaching. The participants however expressed concern over creating lessons with meaningful integration of computational thinking (technology) aspects within class lessons. Meeting the course of study standards for course subjects such as Mathematics, English, Science, Social Studies including DLCS (digital literacy and computer science) was seen as a major challenge whereby participants felt somewhat to not confident about integrating computing in classroom teaching lessons. The participants also mentioned the need for more seminar training hours to gain fluency in coding and operating STEM robots. A vast majority of the participants agreed with the statement that they would voluntarily take courses on computing if given the opportunity.

Interviews:

During the interview, the participants seemed excited about the opportunity to work with STEM robots such as mTiny and mBot Neo in general. The preservice teachers expressed a sense of empowerment once they were able to create their own code to program those robots. They also however expressed feelings of helplessness and demotivation when faced with complex coding problems and bugs/errors. While the participants found mTiny comparatively accessible due to its simple coding functions, they expressed concern over the use of mBot Neo for children who were in middle school. They found it complex themselves and deemed it more relevant for high school students. Similarly, the participants echoed similar concern over children's use of robots and that it might end up being perceived as a toy rather than a STEM robot which has a learning purpose. Finding a true integration in lesson planning and execution was another concern that was brought up by the participants time and again. Although the participants felt they were theoretically well equipped to explain computing concepts such as loops, variables, codes to the students, they did not feel as confident about running and teaching practical applications on the same. The participants also expressed lack of real motivation in attending PEPTICC Seminar when preservice teachers are required to attend the seminar, but it is not a 'graded' course in itself. As such, participants are not as invested in having a learning attitude and motivated to master the training content when they feel burnt out with their ongoing course enrollment.

Discussion

The results from pre and posttest assessments indicated that PEPTICC seminars were mostly effective in equipping preservice teachers with skills and knowledge on computational thinking. Their confidence level when it comes to integrating computing in K-6 subject teaching in a way that is meaningful and adheres to Alabama course of study standards for K-6 subjects as well as DLCS was medium. The participants expressed the need for more practice sessions on coding and time to 'tinker' with the robots to master their coding skills and think creatively about their lesson plans and integration of computational thinking. Participants were also concerned about the viability of such integration and school's as well as student's access to technology and STEM robots. Issues of funding, implementation, and sustainability of computing integration as such in public schools were touched upon by seminar participants in their informal conversation. The participants also expressed feelings of 'burnout' when attending PEPTIC seminars in addition to their undergraduate courses.

Use Recommendations

- Given PEPTICC Seminar is mandatory for Preservice teachers at the University of South Alabama, enlist PEPTICC Seminar as a graded course or assign students with extra credit for their participation in the seminar to increase student's motivation and cultivate a learning attitude amongst them.
- At the beginning of the seminar, provide each cohort with a brief background of the project, the context in which it is situated and being implemented, its objectives, and relevance for the preservice teachers and K-6 teaching.
- Increase the number of training hours and frequency giving students enough time to become comfortable with the robots and engage and learn from 'problem-solving'. If possible, distribute robots to students at the beginning of the seminar so that the students have ample time to tinker and experiment with the STEM robots to help gain fluency and confidence in their coding abilities.
- Provide sample lesson plans as well as demonstrations of K-6 teaching that exemplifies true integration of computational thinking concepts with English, Science, Social Studies, and Math teaching.

Meta Evaluation

The project carried meta evaluation at three different stages of the evaluation process. Once the theoretical design, process, and methods for the evaluation were finalized, the first iteration of meta evaluation was carried right before design implementation. The design was reviewed and vetted with the help of an external evaluator. Based on the feedback, revisions to the evaluation design were made prior to implementation. Some of the notable changes that emerged from the first iteration of meta evaluation was to add qualitative methods/interviews in addition to quantitative method i.e. survey to validate and corroborate findings. Midway through the evaluation process, another meta evaluation was carried out to gauge whether the evaluation was going as planned and if there were any challenges, roadblocks, or contingencies in the implementation. Minor midcourse adjustments to the evaluation plan such as changes to the survey questionnaire, number of interviewees were made. As the evaluation is close to being concluded, a final meta evaluation will be done to review the overall process, findings, and decide on what and how to communicate findings and recommendations with the stakeholders.

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