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Training K-12 teachers to deliver cloud computing content: a case study

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Abstract

Activities to increase K-12 students' interest in STEM fields and computing in particular are growing rapidly and universities are using these to create a pipeline into their schools. Coding-type activities are common and have shown some impact; however, there is more to computing than coding, and there are many more career opportunities in areas like cloud computing. Therefore, research into K-12 cloud computing activities to increase interest in STEM is important. A major obstacle was that many high school computing teachers are not well versed in cloud computing (Pritchett et al., 2013). As a result, any research into the impact of K-12 cloud computing activities would first involve training the trainer or teachers. This paper discusses efforts to train-the-trainers by teaming with the Amazon Web Services (AWS) Academy and using their courses for content knowledge and certification in addition to researcher-created material, virtual classes, and one-on-one mentoring for content knowledge and instruction implementation. Some of the topics discussed here include the training, its challenges and benefits, teacher implementation of lessons, and potential impact for K-12 students and the workforce of the future.

Keywords: K-12, professional development, AWS, certification, cloud computing

Introduction

Efforts to increase students' interest in STEM and computing in particular are abundant and seek to create more interest and awareness to help students pursue careers in these fields (Duran et al., 2014; Forssen et al., 2011; Schneider et al., 2013). A lot of the efforts in computing focus on coding and fundamental computer science concepts. However, there are many other areas that are neglected despite their importance (Sands et al., 2018). One of these skills is cloud computing, which is becoming more important by the minute (Foster et al., 2018). Facing this reality, we recognize that cloud computing skills are essential in the computing job market. IT Career Finder, in its overview of the top required computing jobs in 2023, lists cloud computing as the number one skill and acknowledges the shortage of qualified cloud computing professionals in leading cloud platforms like Amazon Web Services (AWS), Azure, and Google Cloud (Stevens-Huffman, 2022). The author of this report admits that the industry is facing a significant skills gap in cloud engineering and similar jobs, which need to be filled in the near future with qualified specialists.

As a result, targeting cloud computing as a model to bring more diverse computing knowledge into the K-12 curriculum and increase students' awareness is important. The ultimate goal is to widen their prospect of possible computing careers and increase their interest in pursuing them. A grant from a local foundation,

Claude Worthington Benedum Foundation, funded activities to introduce AWS Academy (Amazon Web Services Academy) materials in high schools' computing curriculum. To achieve that, part of the grant was dedicated to training the K-12 teachers on AWS cloud computing. According to the grant terms, a group of high school teachers from four different schools in a tri-state area participated in the AWS Academy Cloud Foundations (ACF) course. All teachers had previous experience teaching computing in the high school and intended to implement the AWS Academy content in their curriculum. This paper presents the effort and results of this case study, and reports the teachers' experiences of this partnership between the University and the high schools.

Cloud Computing and AWS

Cloud technologies have a brief history, but within the past decade they became an essential part of our lives and nearly every organization. Most organizations are either currently using cloud services or exploring ways of switching to the cloud (Gaur et al., 2017). AWS remains the top cloud service provider with a 33% cloud market share at the end of 2022. Microsoft, the next biggest cloud provider, ended 2022 with a 23% market share (Haranas, 2023). Most Fortune 500 companies and 90% of Fortune 10 companies rely on AWS solutions and utilize the AWS Partner Network (APN) in their businesses (Simplilearn, 2023). With 26 regions, 84 availability zones across the world, and over 200 services, AWS heads the list of the cloud service providers in 2023 (Zang, 2023).

In addition to maintaining its position as a cloud service provider, AWS oversees multiple educational programs, grants, and other incentives. AWS Academy is the central platform designed for teaching cloud architecting, cloud development, data analytics, and other areas to college students. The AWS Academy was launched in 2016 and partnered with multiple colleges offering free training to the faculty interested in delivering AWS courses to their students. Since then, hundreds of colleges and universities throughout the world became active members of the AWS Academy, delivering AWS cloud courses in their curricula (AWS Academy, 2023). The authors of this study are affiliated as one of the first universities that partnered with AWS Academy in 2017 and trained its faculty to deliver the AWS Academy courses.

One of the most valuable assets of the AWS Academy programs is the Infrastructure-as-Code (IaC) virtual labs. Unlike simulated labs, in a virtual lab, the resources and a temporary account are provisioned for the students in the cloud environment (usually for a few hours), and after the lab is completed, these resources are released to the pool, and the account is deleted. Such training is entirely based on the cloud tools and on the concept "Everything-as-a-Service" (Qasem et al., 2019). For example, if a student is learning a big data analytics platform, a virtual machine or a cluster can be temporarily provisioned in the cloud, giving the student real-life experience working with this platform (Wang et al., 2022).

Literature Review

STEM and Computing Education in High School

Researchers identify many reasons for which up-to-date STEM programs in high school are extremely important (Gomez & Albrecht, 2013; Thompson, 2023). First and foremost, studies have shown that such programs help the students to develop STEM knowledge sooner rather than later in life and help prepare them for college and careers. For example, Duran et al. (2014) researched an impact of a rigorous after-school computing/STEM program and demonstrated that the students enrolled in the program not only developed a significantly better knowledge of computing/STEM concepts, but also a "change in attitude toward computing/STEM and career aspirations". Additionally, studies have shown that such changes are

especially true for underrepresented groups, such as low-income and minority students, who are underrepresented in STEM fields (Schneider et al., 2013). Aside from the specialized courses and extracurricular activities in school, there are very few chances for the above-mentioned groups of students to be exposed to the computing/STEM field. Specialized computing programs in high school can increase not only the students' interest in computing in general, but specifically address a gender gap in computing programs in college, and further in the workplace. Forssen et al. (2011) conducted a study on a three-year high-school STEM program funded by NSF and found that female students showed a substantial increase in their interest toward computing programs.

Train-the-Trainer Model in K-12 Computing

Qualified and knowledgeable teachers are critical in delivering STEM courses in the high school curriculum. Nguyen and Redding (2018), in their study of the changing demographics of STEM teachers, found that high quality education and certifications help in improving the qualifications of the STEM teacher workforce. Additionally, high school teachers who maintain professional certifications are more effective in the classroom. For example, Reimers (2005) demonstrated that computing certified teachers had a significant positive effect on the level of achievement of their students in Computer Application and other technology courses. Professional training is extremely important in teaching computer science and other related areas. Studies have shown that it significantly increases the high school teachers' self-efficacy and the quality of their teaching in computer science (Zhou et al., 2020).

While many researchers state the importance of training and certification for K-12 teachers and link it with the students' performance (Filderman et al., 2022), very few studies focus on the specific areas of computing and on the training that fits these areas. A few similar training programs were successfully implemented in quantum computing, proving that a correctly designed program can help "improve students' ability to imagine the future and to aspire to STEM careers" (Satanassi et al., 2021, p. 1). In designing similar programs for high school students (grades 9-12), Angara et al. (2022), noted the importance of adapting the contents for the school students, which includes simplifying the theory, providing workshops and other hands-on experiences, and possibly mapping the concepts to real life experience. These common-sense principles can be transferred to other technical areas taught in high school.

Training teachers is a costly process, and in many schools, it is nearly impossible due to the lack of funding. The use of grants or government funding can be a solution in some cases by paying for the training design and delivery, and providing scholarships to the teachers as an incentive to receive the training. Similar grants were awarded during the pandemic and provided substantial help to the teachers in switching to the virtual teaching environment (HT Digital Streams Limited, 2020). In another case study, Indiana University – Northwest was able to implement the computer science training program with local high school teachers resulting in a substantial increase of the schools' computer science teaching capacity (Targeted News Service, 2020). The training was delivered virtually through multiple instructors in participating colleges and universities. In each train-the-trainer case, the authors found a great benefit of such training to the K-12 teachers and students.

Research Questions

To expand high school STEM and computing education to include cloud computing, a project to train K-12 teachers was developed. This project addressed the following research questions.

- **RQ1**: *What are the challenges and benefits of training high school teachers in cloud computing?*

- **RQ2**: *Did the collaboratively developed lessons increase K-12 awareness and knowledge of cloud computing?*
- **RQ3**: *What is the impact of bringing cloud computing to high schools on the workforce of the future?*

Data were collected throughout this experience and although the current data analysis provides some good answers to the first two questions, follow-up data collection will be needed to determine the impact on the workforce (RQ3) as it requires long term monitoring of the trained teachers and the students they taught cloud computing to, to determine where or whether they go to college and whether the courses had a positive impact in the workforce. Therefore, this paper discusses RQ1 and RQ2.

Training Process and Methodology

Training for the teachers was designed as a series of technical sessions using the AWS Academy Cloud Foundation course (AWS-ACF) and individualized team designed sessions. The participating high school teachers were expected to complete the training and take the exam to become certified as AWS cloud practitioners. This would prepare them to subsequently deliver cloud computing content to their students.

AWS Academy Cloud Foundation Course

The AWS Academy training required a minimum of 30 hours of work by the trainees. The AWS Academy is sufficient to build the base knowledge in cloud computing and AWS services. It provides multiple hands-on lab activities to allow the trainees to experiment with the services and learn how to use them. In addition, the AWS Academy learning management system (LMS) offered a large variety of videos, knowledge assessments, practice labs, demonstrations, and documentation to keep participants engaged. Generally each module had a knowledge assessment, short multiple choice quiz, and a lab session guiding the trainees through the use of some relevant AWS service(s). The AWS Academy claims that this course and several others can be used independently as self-study to learn and master the content. However, the researchers' experiences with students in undergraduate/graduate cloud computing classes showed that it is more beneficial for the trainees to have live interactions with an instructor to help them through the AWS Academy. As such, this project was designed for additional live interactions with two of the team members which the teachers were required to attend.

Supplemental Team Training and Mentoring

High school teachers are usually very busy and have difficulties finding time for training. Therefore, the supplemental team training was conducted virtually to allow teachers to join from their locations, thus saving a commute to campus. Sessions were also recorded to allow the trainees to view them offline and review the topics at their own pace. Eight (8), one-hour weekly sessions were scheduled with topics based on the AWS-ACF course provided by AWS Academy.

In each session, the instructors started by providing a brief overview of the AWS Academy module content, explained some of the key concepts, and related them to specific cloud computing features. The teachers were encouraged to ask questions and comment on content at any time. During the sessions, the instructors also used the AWS console to demonstrate the different services and walk the trainees through the process of defining, configuring, and deploying certain services like compute, storage, or network services. The teachers had to work on their own to go over the AWS modules and complete the assignments.

Toward the end of the training period, the sessions included a review and preparation for the exam with additional material provided about the exams and some sample tests. The instructors went through sample test questions and explained how to read and digest the question to find the correct answer(s). Teachers were encouraged to obtain the AWS Cloud Certificate.
With the conclusion of the training, the trainees were ready to take the cloud computing concepts to their classrooms. At this stage, we worked with them to help set up their instructor accounts on the AWS Academy LMS, create classes, and enroll students in these classes in preparation to teach. Throughout this training period and later when the teachers started teaching the modules, one-on-one connections with the teachers were maintained to help them through the process, offer advice, and help them with any technical issues.

Methodology

This research utilized case study design. Due to the individualized nature of the training and the grant budget, participation was limited to six teachers from four schools. Training data included attendance at interactive sessions and AWS Academy Certificates. The data collected from the teachers included (1) feedback about the training, (2) reflections about their experience teaching the modules to their students, and (3) the students' feedback about the modules that were taught to them. The first two items were given to the teachers as essay-type questions and data were analyzed for common themes. Student knowledge and feedback were collected via online pre- and post-surveys. The instruments were prepared by the team and used to study the results, identify issues and challenges, and enhance the entire process for the future. Analysis of survey data was conducted using descriptive statistics (frequency tables).

Findings

Like any project, the measure of success is determined through thorough evaluation of the activities and their results. Some good results were achieved and some challenges arose. Consequently, recommendations for improvements for the future were identified. The following offers some possible answers to our initial research questions.

Outcomes

The training and certification process was long, but necessary to prepare the teachers. Teachers attended on average 70% of the supplemental team training sessions. In general, most teachers were actively involved in the training. However, towards the end of the process, there was less enthusiasm and interest among some of the teachers. They cited other responsibilities as one of the main reasons. Teachers progressed through the AWS Academy modules. Two of the teachers became certified as AWS Cloud Practitioners and four were given instructor status based on the supplemental team training provided. Training the trainer, using the combination of the AWS Academy class, and the supplemental team training, increased teacher knowledge in cloud computing.

The next step was for these teachers to provide instruction to high school students on cloud computing. One teacher dropped out completely and did not teach the modules at their school. The rest taught several modules and provided the results. Teachers were asked to reflect on the training process and teaching the modules in their classrooms. Their responses varied from very positive to somewhat good. For example, one teacher was very enthusiastic about it and decided she will continue to teach these modules in their upcoming classes. Some provided positive feedback, but did not mention future use. In addition, when we contacted the teachers for a second round of teaching, a very small number responded and completed the

round. It is unknown if this was a reflection of their high school course schedule for this second round or if there were other factors involved.

Five teachers provided instruction on AWS, and students in those classes were administered a pre-survey to collect data on their knowledge of cloud computing. Responses indicated that 29% had no clue what cloud computing was, 36% had heard of it but didn't know what it was, 32% were a little familiar with cloud computing, and 3% were very familiar. After the high school students completed the modules, students completed an exit or post-survey in which they were asked to rate their level of knowledge in cloud computing, and 33% rated themselves beginners, 50% intermediate, and 17% didn't know how to rate themselves. Additionally, six multiple choice questions within the exit survey assessed content knowledge. Students scored over 80% on defining cloud computing and how to access and use AWS resources. They scored lower on identifying specific cloud applications and EC2 Instances. Teachers also used various forms of formative assessment within their instruction. Teacher records of student performance on these assessments further supports that students gained knowledge and understood the concepts within cloud computing.

At this point in time, minimum data could be collected to address RQ3. One question within the exit survey queried students on what they were interested in studying in college, and 67% indicated they were considering computer science.

Discussion

Challenges

One of the biggest challenges in this project was recruiting the teachers and keeping them engaged and active throughout the project. The recruitment efforts took a long time as responses were slow to come in. In the end, six teachers from four schools were successfully recruited. After that, scheduling the training sessions at mutually agreeable times was challenging. The teachers had different schedules and various responsibilities, but a schedule was set up that accommodated the majority. As a result, the training team decided to record the training sessions for those who might miss them and for all teachers to revisit them when needed. During the training period retention was a challenge. One teacher started missing sessions and one completely stopped interacting with the instructor and the team. They cited being busy with other tasks and sometimes personal issues as the reasons for missing sessions or not connecting. Fortunately, the training sessions were completed and some of the teachers started preparing for certification. However, only two took the exam and became certified, so this made it more difficult to set them up and have them teach the modules to their students. Another challenge was setting up workable schedules for the teachers to introduce cloud computing in their classes as by the time they completed the training and certification efforts, it was getting close to the end of the academic year. This also created some issues from the researchers' side as more time was needed to prepare some of the assessment tools, especially the exit survey, because some schools had earlier end dates to their school year than others, and this was not accounted for.

Another challenge was conducting extracurricular activities for which were planned and budgeted. The possible activities included traveling to events such as the AWS Summit, cloud-a-thons, the University gathering, and others. The research team believed such activities would have been extremely beneficial to the students interested in cloud computing; however, due to the busy schedules and state assessments in the high schools at the end of the year, there was little interest from the teachers in adding any extracurricular activities.

Recommendations for Successful Training Programs for Teachers

At the end of the program, feedback about the training was collected from the teachers in the form of reflections. All teachers were satisfied with the program and reported that it was useful in preparing them to teach cloud computing content and that the cloud computing content provided helped them teach these concepts in their classes. There were only a few recommendations for improvement. Based on the responses collected from all but one teacher who did not complete the training, the following recommendations were identified:

- Define clear expectations of what the training will be like, how to get certified, and what the requirements are in implementing the training in the high school curricula. At the beginning of the project, a lot of time was spent on recruitment and general preparation efforts. The team believed that the expectations were clear enough from the recruitment information and commitment letters the teachers signed. However, the teachers indicated the need for more detailed information and clearer directions to the teachers. This information will be used to enhance the materials and provide more information for the teachers who decide to participate in the future.

- Align the content to the high school students' level. This was a particularly valuable insight, considering that the AWS Academy training was created for adults and not K-12 students. To be able to align it to the high school level, terminology needs to be simplified and facilitated with the appropriate examples, and complex computing concepts should be avoided. For example, as the teachers admitted, many students were the users of social media such as Snapchat or Instagram, not realizing that they are part of the cloud. The same students "hated computers", while spending most of their time on social media. The teachers believed their learning of the cloud technologies will improve if they associate the cloud technologies with actual real-life applications. This can be addressed in the future by looking into better ways to tie the cloud computing concepts to real-life applications and create an environment where the students can actually see how the applications they are using work on the cloud.

- Teachers also suggested additional student-center assignments, possibly even creating simple applications of their own. Addressing this will require more preparations from our team and higher involvement of the teachers as they will need to invest more time and effort implementing such changes. For example, for the students to create a simple application and deploy it on the cloud, they will need prior development knowledge that the teachers will help them connect with the cloud computing concepts.

Overall, the outcomes are encouraging and merit a revisit to this experience with more comprehensive coverage, higher K-12 teachers' involvement, and enhanced training and teaching methods. One of the most important aspects is working on finding better cloud computing courses in AWS Academy or other cloud providers' resources or additional supplemental training and mentoring. The key is to use a more flexible and customizable cloud computing learning environment that will allow the redesign of content and create modules catered specifically for K-12 students. This will also require the inclusion of more training components for the teachers to be able to use such an environment and further customize it to their specific students' needs.

Expectations

The ultimate goal of this project was to create a positive impact on the future workforce in the region. However, this long-term goal could not be measured at the present time as high school students participating in the instruction will not yet enter college or graduate for several years. When discussing future impact, the student reports of interest and some estimates or predictions can provide some insight until the students actually enter the workforce. The feedback received from the teachers and students indicate some positive effects towards that goal. There is increased interest in the cloud computing field among the teachers and students as a great deal of the students involved in this project are targeting STEM related college educations, many in computing. Some teachers expressed their positive views and willingness to continue teaching cloud computing in their classrooms, and the research team are encouraged to pursue similar efforts in the future to strengthen this impact and move closer to achieving the goal.

Conclusion

In the course of this project, benefits and challenges of the training program to the teachers were identified. While the obvious benefit was the possibility to introduce cloud computing in the high school curricula and generate the interest of participating students in the topic , we determined that the future training programs will need to be better adapted to the high school students' level and interests. The content of the program (which did not present much difficulty to the students) needs to be placed in a context that is more familiar to the younger audiences. The project showed that there was an undeniable interest in cloud computing among the high school teachers and students in advanced IT programs. Despite the small sample size, the training program developed was well-organized and scalable. When interest in the topic increases, it will be easy to include and train many more teachers. Although the present results did not include sufficient information to answer the research question related to cloud computing in the future workforce, it is the researchers' intention to work on this during the remaining course of the project.

In conclusion, we are grateful for the funds provided by Benedum Foundation to educate high school teachers and students in cloud computing and thus having a positive impact on the future workforce by providing essential skills for the future graduates. It is no surprise that Pittsburgh was just chosen as one of the major workforce development hubs in the country; we have the full commitment for teachers and graduates to have the skills that will help them in STEM employment, thus, improving the quality of life for them and the region.

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