

Educating the STEM Leaders of Tomorrow

Attracting K-12 Students to Computing Careers

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Abstract— In this paper, we discuss our contribution to the field of computer science and education technology through various projects we have designed and implemented at Auburn University. We begin by introducing a very successful computer proficiency course called Personal Computer Applications (PCA). The goal of this course is not only to impart useful computer skills to the students but also to attract them to computer technology so that they can solve problems and make better decisions in their day-to-day lives. Then, we discuss two more courses designed and offered by us in the area of web development. This paper particularly discusses our unique teaching methodologies and how these techniques led to the success of our courses. Finally, we discuss our contribution in introducing young kids to the world of programming, and encouraging women participation in technology. We achieve these two goals through our K-12 camps offered on Auburn University campus.

Keywords—PCA; Content Management System; Web development; STEM; K-12

I. INTRODUCTION

The definition and use of computers has changed drastically since the 19th century, when they were invented. Computers are no longer used for mere calculations; they are capable of performing extremely complex tasks and have become an integral part of our daily lives. Computer use in today's world is so pervasive in society that even children are exposed to it. Often, the kids are subjected to an unstructured learning environment that causes them to expend a lot of effort to learn but they cannot learn a lot. Historically, male have dominated the field of computer science and information technology. In 2012, only 18% of the overall computer science degrees were awarded to females. At Auburn University, our endeavor is to increase the participation of children and female population in the field of computers and technology. One of such endeavors is our annual K-12 camps that are dedicated to address these two concerns.

A. Motivation

The primary motivation for writing this paper is to highlight the techniques we use to impart computer science and technology at Auburn University (AU) so that they can be adopted by others and using these techniques, we can together contribute to the growth of the nation. Technology is a tool that give people strength to have greater control over their lives,

bodies and mind and also be able to do their jobs at / from home. The human-computer interaction has increased and will become more “natural” in the forthcoming years. Recent studies [2] forecast that by 2018, 51 percent of STEM jobs will be computer occupations (Fig. 1). Another projection from the Bureau of Labor Statistics 2008-2018 Employment states that 75% of the engineering jobs in the U.S. are going to be in computing. There is a high demand of people with basic Computer skills in the market. According to a New York Times article, there is a 6% unemployment rate in the area of Computer Science (CS). At AU, we aim to foster the interest of our students to learn and develop technologies beginning at the classroom level.

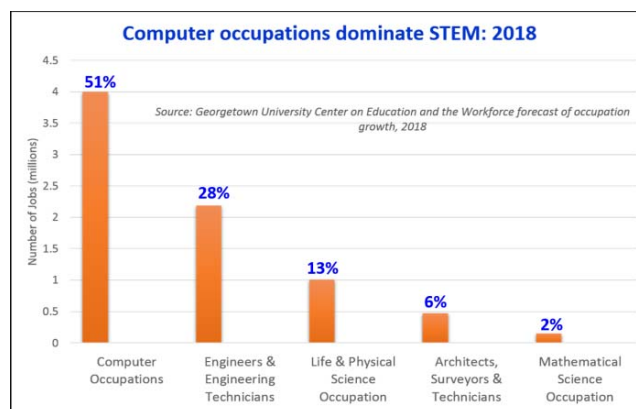


Fig. 1: The study shows that 57% of the STEM jobs by the year 2018 will be in the field of Computers.

II. CONTRIBUTION TO THE AREA OF COMPUTER FLUENCY

One of the most popular courses offered at AU is Personal Computer Applications (COMP 1000). COMP 1000 is one of the few courses offered every year in all 3 semesters: Fall, Spring, and Summer. Every semester, more than 800 students from non-engineering majors enroll in COMP 1000. Some students use this experience to broaden their knowledge about computers and the application of these skills in their daily lives, while others simply enroll to fulfil their degree requirements.

In our courses, we teach students the uses and features of the latest version of Microsoft's Windows Operating System as well as the core Microsoft Office applications: Word, Excel,

Access, and PowerPoint. Students also learn to use Microsoft SharePoint to build and customize websites. PCA covers many of the more advanced features of Microsoft Office. Roughly 25% of the semester is devoted to teaching Microsoft Excel and PowerPoint applications due to the high demands for these two applications in the market. Another 20% of the semester is spent teaching the skills required to design and maintain websites using the more advanced features of Microsoft Office integrated with Microsoft SharePoint. Assuming that college students have basic knowledge of PowerPoint, we cover some advanced topics such as creating and customizing PowerPoint templates, financial formulas, flow chart and other advanced features to match the curriculum of our business school as well.

The official website for PCA can be found here [3]. Prentice Hall, a leading publishing company for information technology courses, is the provider of the course's custom text book and web-based training for Microsoft Office applications. The custom edition for AU consists of two textbooks: Microsoft Office and Microsoft SharePoint, in addition to an access code for use with the web-based training. Pearson Education offers web-based testing solutions worldwide through their web-based applications and their secure servers. We have established a partnership with Pearson Education, and use their MyITLab simulated environment for all of our Microsoft Office material in which students practice the topics taught in the classroom via their web-based training. All of the exams required for our course are administered through MyITLab's skill-based assessments as well.

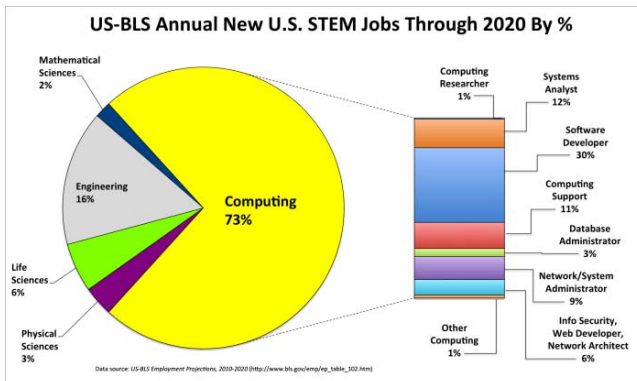


Fig. 2: Rising computer engineering jobs in STEM

A. Motivations

There is no common set of skills that can be applied to every job position in the market. But there is a certain set of skills that are "in-demand" for most of the jobs. In their research, IDC [4] analyzed 14.6 million job postings to identify skills needed for high-growth jobs by 2020. Through this analysis, they identified 100 skills that are required by almost all occupations in the U.S.A today until the year 2020. The only software package found in the top 20 skills out of 100 was Microsoft Office. Microsoft Office was found to be at number 3 on the list of the top 100 skills required by all occupations. Furthermore, Microsoft PowerPoint and Microsoft Word were number 11 and number 13 respectively on the same list. In our PCA classes, 40-45% of the semester is spent teaching Microsoft Word and Microsoft PowerPoint. Two of our three

exams are dedicated to these two applications. This ensures that students understand each of these two applications thoroughly.

B. Teaching Methodology

PCA is a two credit hour course and the class meets twice a week for an hour at a time. A team of qualified graduate teaching assistants (GTAs) are appointed to teach this course. These GTAs are working on their masters or doctoral degrees in Computer Science or Software Engineering. The GTAs instruct the classes and help students work on their hands-on assignments during class. There are two types of assignments that students are required to complete every week: in-class assignments and online homework assignments. The in-class assignments are done by the students in the presence of the instructors in the class, while the online MyITLab assignments are completed by the students at home as they are based on the topics already covered in class that week [5]. The documents that students work on during class are saved to their OneDrive accounts. Each student has an Auburn University OneDrive account to save their work for later access. With this methodology, students learn the advantages of saving their documents to the cloud. The weekly MyITLab assignments are very engaging since students use a simulated environment for Microsoft Office, and consequently tend to retain the concepts longer. As it is said, rote learning kills passion about computers [6], all of our assignments give students hands-on experience with the technologies taught in the course, and there is always an emphasis on problem solving in our classes. The course's website and Canvas are the official sources of class information. The course syllabus, exams, assignment schedules, grades, student resources, and all other course-related information that students need are posted here [3].

C. Online PCA

For the convenience of our students, we offer the PCA course online. This is facilitated through the Distance Learning office at the Biggio Center in Auburn University. Students who are working as full-time employees or cannot attend classes on campus have the option to enrol in the online version of the PCA class. Students taking the online course are given the exact same assignments assigned to on-campus students and take the same exams through our testing services. The number of student who enrol in the online class are always fewer than the students who enrol in the on-campus version of the course (Fig 3.), as only one online section is offered each semester.

D. Competency Section

For students who are required to take Comp 1000 and believe that they already possess the skills and knowledge taught in the Comp 1000 course, a competency test is available. The competency test is administered online, free of charge, using Pearson's MyITLab website, and covers all of the topics taught in the Comp 1000 course which includes Windows 8, the core Microsoft Office 2013 applications, and SharePoint 2013. The competency test is offered in the fall and spring semesters and must be registered for just like a regular course. The competency test is a zero credit hour course, and can be taken only once. A student's test is graded as "satisfactory" or

"unsatisfactory". If the student scores a 70% or above on the competency test s/he will receive a "satisfactory" grade and will be exempted from taking the Comp 1000 course, otherwise s/he will receive an "unsatisfactory" grade and will be required to take the Comp 1000 course.

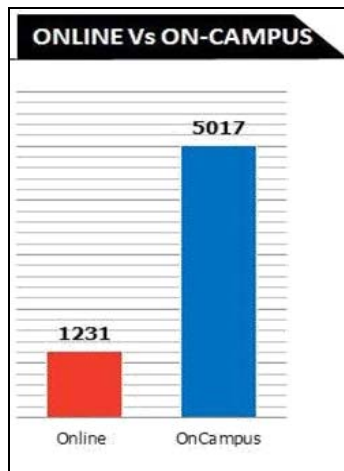


Fig. 3: More number of students enrol in on-campus PCA classes than students who take the online version of this course at Auburn University. The graph shows the same data over the last 5 years (2010-2014)

IV. CONTRIBUTION TO THE AREA OF WEB DEVELOPMENT

In this section, we discuss our contribution to the area of web building technologies. We offer two courses, namely Network Programming with Java and HTML (COMP 2000) and Web Application Development (COMP 5000/6000). These two courses are offered once a year, and due to their wide application range, students from various majors enrol in them.

A. Motivation

Our motivation to offer these two courses at AU is the rising need for web developers in the today's industry. According to the Bureau of Labour Statistics [7], there is a 20% employment growth projection for web developers by the year 2022. Another factor that attracts more graduate students to the area of web design is the popularity of e-commerce and the need for experts in this area. As more and more companies expand their businesses to offer their services and merchandise online, there is a rising need for web designers and developers in the industry. Another report from AboutTech.com [8] lists the top 10 skills desired in a good web designer. The top 4 skills are HTML, CSS, JavaScript, and Ajax. All of the mentioned reasons are the driving factors for us to offer our web development courses and prepare students for these exciting job opportunities.

B. Teaching Methodology

The web application development course (COMP 5000/6000/6006) is offered for undergraduate, graduate, and off-campus (distant learning) students. In this course, students are taught the concepts of Extensible Markup Language (XML) and Java Server Pages (JSP) technologies. The

students are also given free access to various web development IDEs required to develop solutions for the project and homework assignments. Throughout the semester, we assign 5 short homework assignments to the students:

- For the first homework assignment, students create an XML Compound Document and validate it with Document Type Definition (DTD).
- For the second homework assignment, given an XML file and a stylesheet, students validate a document using Schemas.
- Third, students build XML Applications with Extensible Stylesheet Language Transformations (XSLT)
- The fourth and fifth homework assignments are based on JSP technology. Students create real-time applications where they learn how to link JSP pages with a SQL database.

COMP 2000 provides learners with the latest knowledge, skills, practice and experience in developing Web pages and Web sites using HTML 5.0, CSS 3.0 and JavaScript, assuming that learners have little or no programming experience. It consists of two conceptually different parts. The first part is about designing and developing Web pages and Web site with HTML 5.0 and CSS3, using multimedia on the Web, and creating dynamic Web pages using with JavaScript. The second part introduces learners to Internet concepts, E-Commerce and the Web, and Accessibility standards.

V. K-12 OUTREACH

Building a foundation of scientific and engineering fundamentals early in a child's life is one of the most effective methods of promoting a desire for further education in the STEM fields. Unfortunately, various studies have shown that interest in scientific fields may be dwindling due to a belief of limited creativity and lower innovation than other fields. By using a hands-on approach as a catalyst, the CS4 camp is designed to create and promote interest in computational reasoning and engineering skills in middle school aged children. By allowing the students the creative freedom and supplying them with the resources and knowledge base that they would need to accomplish their tasks, the camp effectively dispels the notion that there is limited creativity[10]. Using Kodu, App Inventor, and Lego Robotics we are introducing engineering concepts in interesting ways that appeal to the creative side of the students while simultaneously incorporating analytical thinking and problem solving skills.

A. Motivation

In our K-12 outreach programs we aim to encourage K-12 students to pursue STEM careers, especially engineering, with special focus on girls, students with disabilities, and students from underprivileged areas who may have more apprehension towards pursuing such degrees. In today's world it is becoming more and more important for us to develop problem solving skills, and become fast, independent learners. In our camps, we expose students to different areas of Computer Science and Software Engineering including game development, 3D animation, building programmable robots, mobile device

application development, and even 3D printing. We work with them to encourage their creativity in design and problem solving using these technologies.

B. Methodology

Robotics is an interesting way to introduce, or augment, interest in STEM topics. During the CS camps, Lego robotics was offered to students as a possible course of study and students who participated were able to gain hands on experience with basic engineering concepts as well as high level programming practices. The robotics camp itself follows a lesson plan, starting with assigning the students to groups and introducing them to a basic robot build, complete with construction instructions. Once the various groups have constructed their first robots they are introduced to the coding software used to program the Lego NXT and EV3 robots that they are assigned to work with. This stage of the camp introduces programming basics with robotics to the students who are asked to create simple programs that will enable their robot to move. After this point the students are encouraged to create their own designs to complete tasks, such as move quickly, or navigate around obstacles using the Lego sensors that are available.

Although the camp is oriented around showing students concepts for computer science and programming, the robotics portion of the camp also provides an opportunity for students to explore engineering and physics concepts as well. When creating their own designs, or modifying the basic design that they started the camp with, students must problem solve structural issues, making sure they are able to include their desired sensors and motors in beneficial ways and learning reinforcement methods to increase structural integrity, making sure their parts do not fall off easily.

Physics plays a large part in the competitions that the students partake in among themselves, one such competition involves racing robots across a table. The difficulty of such challenges are that all parts have the same physical capabilities so the students must think of potential ways to make the wheels spend faster than the motors themselves. The students also learn programming techniques and are introduced to algorithmic thinking practices when learning to program their robots such as using various data structures and sensors in order to create behavior patterns for a robot to navigate itself around a room. By the end of the robotics camp the students have had some hands on experience with critical thinking in order to solve engineering and programming problems while they compete with each other to create the best robot for the particular task that they are accomplishing.

Recently, we also offered a similar camp for students from black-belt region in the U.S (cs4allb.eng.auburn.edu). The students had very less opportunities with computers before. These students gained hands-on programming experience with Microsoft Kudo and Lego NXT and EV3 robots

VI. CONTRIBUTION TO WOMEN PARTICIPATION IN COMPUTER SCIENCE

A. Motivation

Over the past few years, we have been working towards improving female participation in the field of Computer Science and Software Engineering. The field of Computer Science and Information Technology (IT) has always been dominated by males. In one of the latest reports issued by the National Science Foundation [11], it was found that though the number of women in Computer Science engineering has increased since 1993, the number is considerably low when compared to men (Fig.4). There is a lot of ongoing research that investigates the reasons of less involvement of women in the field of Computer Science and IT. One of such studies [12] that also aims to remove barriers to the entry of women into IT careers lists several findings after surveying women from non-IT fields. One of the reasons due to which these women did not choose IT careers was that they found the IT curriculum to be time consuming, uninteresting, and difficult. Another reason was their concern about classroom environment and fear that they cannot perform as well as their male colleagues.

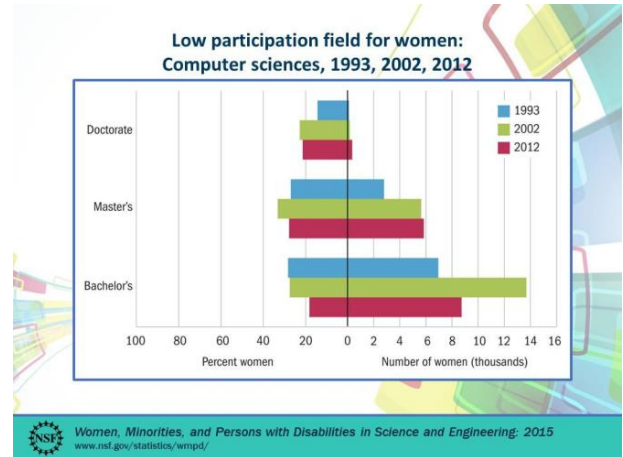


Fig. 4: Women in Computer Science field.(Source:ww.nsf.gov/statistics/wmpd)

A similar trend is observed at Auburn University's campus as well. Fig.5 shows that the number of females enrolled in PCA classes have dropped for last 4 years except in 2014-2015 where the percentage has risen by 2%.

B. Methodology

Through our Computer Science for All Girls (CS4AllG) camps, our aim is to provide an all-girls environment where girls receive adequate attention from the teachers and also do not have to fear their male counterparts who have traditionally dominated the field of Computer science. CS4ALLG [13] is an initiative to foster interest in computers in middle school and high school girls, and encourage them to take up careers in engineering. CS4ALLG (cs4allg.eng.auburn.edu) started as a pilot project which was a 3-day summer camp at Auburn University. This project aims to change the women's perception about CS and provide them with an engaging CS programming experience. Our experience working with these

young girls at these camps as well as our research on engaging learning with technology led us to believe that three conditions are needed to engage girls in CS learning: (a) structured guidance, (b) authentic tasks, and (c) peer mentoring [13]. We have observed that many girls are afraid of exploring new technologies on their own. With girls, sometimes more time and effort goes into discussion than in construction. The curriculum for CS4ALLG has been designed with keeping such factors in mind. Also, much of girls' play in general (like playing house or school or beauty parlor) focuses on strengthening social skills [14]. The focus is on relationships among people or between people and objects. This was one of the motivations that led us to offer on-campus housing for them. The girls stay at the AU dorms for all three days of the camp and build strong relationships among themselves. It has been observed that when girls have a female mentor who succeeds in math and science, they are more likely to pursue degrees in science and technology related areas [13].

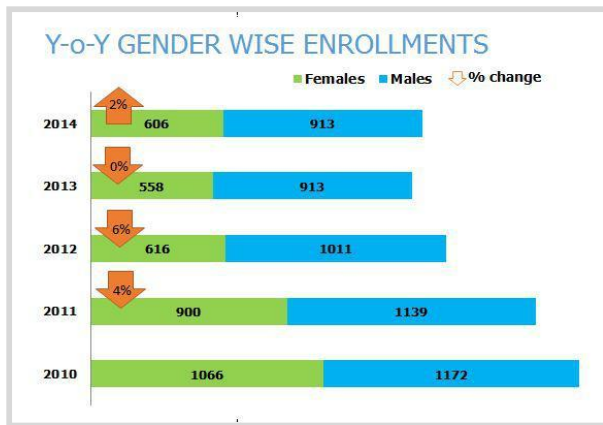


Fig. 5: Widening gender inequality in CS major on AU Campus

In CS4ALLG camps, we only hire female instructors who guide these young girls through the course of the camp. A variety of tools and technologies are used in these camps to break away from the traditional methods of teaching and unleashing new patterns of learning. For the CS4ALLG camp we created a curriculum that uses a combination of CS Unplugged (CSU) kinesthetic activities and Microsoft Kodu. We also used the contemporary flipped classroom method to boost their self-confidence and reinforce the knowledge imparted to them.

Kodu (<http://www.kodugamelab.com/>) is a programming framework that allows children as young as eight to construct computer games or simulations by writing behavior rules for the characters and objects. The main character in this 3D environment is Kodu, and it can be programmed to perform real-life tasks such as run, jump, and say. Due to the popularity of the Kodu character we decided to demonstrate the use of a 3D printer to the girls and print a Kodu character. This was an exciting experience for them, especially when they got to hold the completed Kodu in their hands. At the same time, they learned the capabilities and basic operation

and components of a 3D printer. Our focus was to provide the girls with relational as well as technical concepts during the camp. We love to watch how each girl becomes more comfortable, confident and capable with the skills and abilities gained at the camp.

C. Outcomes

The CS4ALLG camp started as a three-day camp in 2013. This year, due to its popularity and success, the camp was extended to a five-day long camp. On the last day of the camp, students are asked to fill out a post-survey and write their first blog entry by responding to a blog post with questions such as what motivated you to participate in this camp. What do you want to learn or experience during this camp? We asked the girls to record their experiences at the camp through a blog post at the end of each day. An entry in the summer 2015 Camp Blog illustrates what one girl thought about the NAO robot introduced to us by one of our guest speakers.

"Personally, I loved the Robotics Workshop. It was one of the most interactive, fun, and exciting work-shops I have ever seen or been in. My favourite part was probably the walking that we did with Nao. I would love to grow up and do something like this in the world." - Alison

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