CAP-B: Increasing Students Expertise and Career Competencies Skills in Networking using Project-based Learning and Blended Practical in a Cognitive Apprenticeship Framework

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Abstract

The digital revolution has created an environment that requires workers who possess the technical and Higher Order Thinking skills to be able to apply knowledge acquired. Educators are now mandated to prepare these desired graduates. For graduates who study Computer Network there is a double challenge to teach this course as the field is a complex and evolving one. Educators must now prepare graduates who understand Computer Networks concepts, have the practical network skills as well the necessary Higher Order Thinking skills.

This research presents a case study utilizing a new methodology based on a merger of Project-Based Learning, Hands-on Learning, Simulation Based Learning, and the Cognitive Apprenticeship framework, which aims to increase students' expertise, self-efficacy and HOTS level. The methodology has been implemented for the past 3 years and analysis of results has shown, despite the changing of delivery mode due to the COVID-19 pandemic, that students were able to (i) acquire and increase their domain knowledge, (ii) acquire procedural and process knowledge while solving problems, in given scenarios (iii) increase their self-efficacy in Computer Networks and (iv) increase their Higher Order Thinking skills.

Introduction

There is an increase in the demand for a computer network (CN) workforce and it is projected to grow 5\% between 2020 and 2030. Although universities and colleges have stepped up efforts in training these technical personnel, the CN field is complex and unpredictable making it challenging to study and teach. CN has a broad range of topics as well as many abstract technical concepts and jargon that are difficult to explain and understand. It also requires practicality to all these topics. The field is also constantly evolving.

The digital revolution has not only increased the demand level for network graduates it also changed the qualifications for graduates. Employees are now asked to not only have required technical knowledge and skills (hard skills) but also competencies in soft skills such as critical thinking and communication. Surveys and reports from Employers show college graduates tend to be lacking the desired level of competency. The 2019 Society for Human Resource Management Report reported that education has “done little or nothing to address the skill shortage” and the Institute for the Future reports that this demand for HOTS skills "seriously challenge traditional [learning] establishments"

Methodology

To achieve these goals, throughout the semester, the researcher employed the different CA teaching methods with the goal of building students’ expertise and to facilitating the transfer of knowledge to real-world situations and problems. As such, students learnt by watching e.g. how to disassemble/assemble a computer, build a patch cable or reset a switch (modelling) then practicing these techniques and tasks through classwork, assignments, hands-on and simulation labs. During these the researcher observed the students and provided feedback and help when necessary (coaching). Students are also given the PBL project in which they could verbalize their knowledge and thinking (articulation), compare and evaluate themselves and their peers (reflection) while they propose and develop a solution to given real-world problem scenarios (exploration). Throughout the semester the researcher provided help and guidance (scaffolding) for the PBL project while increasing the complexity and diversity of assessments.

Lab sessions and the PBL project were given so as to allow students to be able to articulate and explore while developing their CN expertise as well as their HOTS skills. Labs sessions were divided into weekly hands-on exercises and simulations. Simulations were designed to act as the practical component of the lecture. In this way students received practical understanding of the taught concepts. To further cement their practical experience and knowledge students work weekly on a hands-on project which required them to utilize the abstract concepts which are usually hard to understand practically but shown in simulations.

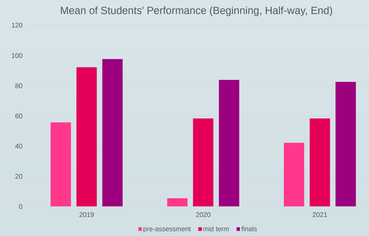
Students are assessed to provide frequent opportunities for feedback, reflection, and revision, in order to enhance the quality of learning. As such the course had formative assessments (discussion forums, observations, hands-on and simulation labs) to provide continual feedback about preconceptions and performances and summative assessments (tests, midterm, final examinations, Simulation and Hands-on Project Report and Demo) to measure the results of student learning..

Results

Examination of Self-Efficacy: Research has shown that change is Self-Efficacy is related to academic performance - the higher the academic performance the stronger the Self Efficacy. After testing students’ academic performance over the 3 years - pre-assessment test (Mean=55.8[2019]; 5.6[2020]; 42.2[2021]) and Final Examination result (Mean=97.7[2019]; 83.9[2020]; 82.6[2021]) it can be concluded that students having completed the course with high sores have a greater sense of SE that when they began. See figure below.

Network Expertise: Examination was based on declarative knowledge (ii) procedural knowledge and (iii) retention level. **Declarative knowledge** showed positive changes for all 3 years from pre-assessment (Mean=55.8[2019]; 5.6[2020]; 42.2[2021]) to midterm (Mean=92.3[2019]; 58.4[2020]; 63.5[2021]) to final examination (Mean=97.7[2019]; 83.9[2020]; 82.6[2021]). providing evidence that students were able to retain much of the theory and its applications, thus being able to answer questions more accurately at the end of the course. **Procedural Knowledge** was examined using scores in final simulation (Mean=87.4[2019]; 86.9[2020]; 80.6[2021]) and hands-on (Mean=87.2[2019]; 71.8[2020]; COVID[2021]) projects. It showed not much difference in the mean leading to the assumption that students were able to attain the same skill level in both hands-on and simulations. 90% of students in survey stated that having simulations practice and then replicating what is done in the hands-on projects helped them learn the material better. Retention Level examined students overall performance.. For the studied university the acceptable pass rate is C and above. For the 3 years pre-assessment showed 78% failed however there were 100% pass rate for all years

Higher Order Thinking Skills: Based on assessments and the resulting results of students there were increase in students Metacognitive skills (Communication, Regulation & Monitoring Skills), Creative Thinking skills (Innovative Thinking, Insight Skills), Problem Solving & Critical Thinking skills (Analytical Thinking, Evaluation Problem Solution Implementation skills)



Discussion

Computer Network is a complex and challenging course to teach and CAP-B is designed as a methodology ton be utilized to help produce graduates that meet employers requirements. As such, it has been designed to improve students expertise in Computer Network, their Self Efficacy as well as their HOTS competencies. The methodology has been utilize in the chosen HBCU since 2019. The purpose of this case study was to identify if these goals are achieved at the end of teaching CN.

From the quantitative analyses it is revealed that CAP-B had increased students' SE, declarative and procedural knowledge as well as retention levels regardless of their prior knowledge background. With this methodology students were able to understand different types of networking concepts, apply the learnt skills in different environments as well as solve problems arising from different scenarios and environments. This conclusion was again supported with qualitative analyses, that showed there is a strong correlation between the amount of time spent doing simulations and Hands-on practices and the increase in students’ expertise level.

Based on surveys students perceive that this blend of simulation and hands-on helped them to understand the concepts and acquire necessary skills. For these students the use of simulations helped them to achieve tasks done in the hands-on exercises. Based on analysis of 3-years of data, this study has concluded that using CAP-B has resulted is a significant increase in students SE, academic performance and HOTS levels. Data will continue to be collected to continue further analysis. Further research will be conducted to test the transferability of CAP-B to other courses that can utilize both HOL and SBL.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant IUSE:EHR 2021203