The Quantum for All Project: Professional Development Model and Teacher Outcomes

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Abstract. The Quantum for All project has developed instructional materials and a professional development program to expand Quantum Information Science education in precollege education. In this presentation, we discuss the design of the professional development plan and the development of the materials by the Leadership Team. We then discuss the workshops for teachers to learn and utilize this content. We will examine growth in teacher knowledge and confidence, and we also examine the variation of these things across content domains as represented by the instructional modules.

Introduction

Quantum Information Science (QIS) will play a critical role in security and economic prosperity throughout society in the future. QIS will play an increasingly important role and in the workplace even among non-STEM careers [1]. The United States passed legislation in January 2019 called the National Quantum Initiative Act to expand the nation's commitment in QIS by investing in activities to develop QIS and technology workforce pipelines. Many relevant documents about this effort are available at the National Quantum Initiative website [2]. An important aspect of this initiative is the need to expand education on QIS topics in precollege education and provide students with appropriate knowledge about content and applications of QIS, since currently there is no clearly defined set of career paths for the Science, Technology, Engineering, and Math (STEM) workforce pipeline to pursue that contains specific QIS connections.

The Quantum for All Project Professional Development Model

The Quantum for All project is a grant from the National Science Foundation in the United States that is designed to address the need for increased education on QIS at the precollege level. participating teachers engage in a 4-day workshop led by members of the Leadership team. These workshops are active, hands-on exploration of the materials designed to develop scientific knowledge, pedagogical knowledge, and technological knowledge around the topics in the materials. This three-component framework is known as TPACK [3]. For effective instruction teachers requires content knowledge about the subject, the pedagogical knowledge related to the subject, and fluency with the technology used in the lesson in order to actually deliver quality instruction. All these elements must be integrated into the teaching process when addressing concepts that may be difficult to understand, as in the case of QIS.

Following the initial 4-day workshop, the participants are provided the opportunity to teach students using the materials and pedagogy they have just acquired in a 4-day student summer camp. The teachers take surveys before and after the 4-day teacher workshop, as well as after the student camp, to assess content knowledge and the expressed self-confidence in that knowledge. Teacher confidence in their understanding is strongly correlated with their score on the content surveys. For example, for the unit on atomic physics, $r^2=0.5076$ for the correlation between survey score (7 content questions) and self-reported confidence level (on a 5-point scale) after the initial 4-day workshop and student camp. The same topic showed growth in teacher understanding of the topic, going from an average score of 4.32/7 to 5.58/7 ($p=0.0005$) after the student camp, but

essentially no change from after the initial 4-day workshop (5.79/7) to after the student camp (5.58/7) with p=0.5374.

Conclusions

Pre- and post-surveys find that teacher participants in the professional development are increasing both their content knowledge and their confidence in that knowledge. In this presentation we will examine details of our findings, particularly comparing content areas familiar to teachers and content areas not familiar to teachers.

References

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