Should We Assess the Haptic Tendencies of Pre-service STEM Teachers?

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Abstract

Previous research indicated above average haptic abilities in students self-selecting into engineering and technology fields, along with a preference for learning from hands-on activities. However, current students are beginning their university studies with little to no practical experience in building physical models, selecting materials, or design analysis and revision. Much of the technical experience they do have is from completing virtual labs and other computer-based instruction which does not always translate into useful abilities in a university laboratory environment. There are also many misconceptions about the practicality of incorporating haptic activities into classroom activities. Thus, the process of testing pre-service teachers and the dissemination of information about the prevalence of haptic tendencies in certain populations, and the importance of incorporating haptic activities into instruction, could have a positive impact on classroom teaching and better prepare high school students for work and study in the STEM fields.

Introduction

Unlike visualization skills, which can be taught, the haptic abilities of a neruotypical adult subject do not change significantly over time. Subjects who have above average haptic tendencies do not necessarily by default have above average visualization abilities. However, those who regularly participate in haptic activities, whether in the classroom or out, tend to have higher spatial visualization abilities and these abilities are pertinent to their success in the STEM fields. Students who begin their engineering and technology studies with poor spatial skills have lower levels of academic success at university. Virtual labs and simulations that are gaining in popularity as part of preprogrammed instruction, but do not incorporate haptic or practical components, do not provide a realistic experience to students and they also do little to improve spatial skills. The use of haptic activities in instruction is a necessary component in improving spatial skills, not only for engineering students but across curricula. A 2005 paper by Sorby, Hungwe, and Charlesworth noted that in non-engineering students who received instruction intended to improve spatial abilities, subjects who only used software for training had significantly lower gains in PSVT scores than did subjects who completed workbook activities that required sketching and the use of manipulatives (snap cubes) to build objects.

Haptics and Visualization in STEM Education

While there are benefits to using virtual instruction in STEM courses, including access to a wide variety of content, potentially lower cost and little/no equipment maintenance, 3D interaction using software is often simplified and does not always accurately reflect actual function which in turn does not yield optimal outcomes of student learning. These results are seen not only in inadequate precollege preparation in engineering and technology, especially in the spatial skills necessary for success in engineering design and engineering graphics courses, but even in performance in required mathematics and physics courses. According to Sourin and Wei (2009), the use pictures or symbols of 3D objects on screen can lead to weakened mathematical competencies when dealing concrete 3D models, analysis of solid figures, and vector analysis. Furthermore, the use of haptic activities instead of non-interactive instruction enhances abstract phenomena when teaching physics (Tanhua-Piiroinen, et. al, 2010).

Much of the current research on incorporating haptic activities in the classroom involves the use of computer-based equipment such as force feedback devices. The price of the equipment that provides the most realistic haptic feedback can be prohibitive, especially in urban and rural school districts where the tax base cannot support higher end equipment. During the preplanning stages of this current study, in discussions with both preservice and inservice teachers about haptic activities, there was a common misconception that the use of computer-based activities and expensive equipment was required along with a need for specialized knowledge. In the case of many engineering and technology courses, especially those in engineering graphics and engineering design however, a variety of low tech activities may be implemented that take advantage of the haptic tendencies of the students and improve their spatial skills, which in turn can lead to higher levels of retention. Activities as simple as sketching and using manipulatives can have a significant impact on student success. Improving visualization abilities by implementing haptic activities as part of instruction in an introductory engineering graphics course improved overall GPAs and GPAs in STEM courses, and also increased both retention in the major and retention at university in a sample of minority engineering and technology students (Study, 2006, 2011).

Current Study

The author of this paper has begun a study to determine if university students preparing to become teachers in the STEM fields have similar haptic abilities as the students they will be teaching; and to educate these pre-service teachers in the importance of using haptic activities and their relationship to the development of spatial skills. The study is being conducted in three phases.

The goal of phase 1 is to gather additional data on freshman engineering and engineering technology students to verify previous research results that indicated above average haptic abilities based on Haptic Visual Discrimination Test (HVDT) scores. Two sets of HVDT testing materials

have been obtained, along with IRB approval to test freshman students over the course of five years. Testing began in the spring 2014 semester on students enrolled in introductory engineering graphics courses. These subjects are primarily freshmen majoring in mechanical or plastics engineering technology, or integrated business and engineering. Course content includes multiview projection, dimensioning, working drawings, creation of design solution alternatives, and CAD. Instruction techniques include sketching and the use of manipulatives along with lecture, demo, and CAD tutorials. Students in the course are administered the Purdue Spatial Visualization Test (PSVT) as a pretest and posttest as part of regular classroom activities and the mean scores for these students have been similar to the expected mean for the given population. HVDT scores collected so far are also similar to the expected mean found in previous research on a population of freshman engineering and technology students (Study, 2001) with scores for both groups at approximately one standard deviation above the mean expected in a neurotypical population.

In phase 2, the assessment of haptic tendencies of university students who plan to become elementary or secondary STEM teachers will be undertaken. Recruitment of subjects has already begun. The primary purpose of this testing is the answer to the question posed in the title of this paper. The intent is to determine if the haptic tendencies of these future teachers are similar to students self-selecting into engineering related majors. Subjects participating in this phase of the study will be instructed in the importance of visualization to success in STEM fields, especially engineering, and the role that haptic activities play in improving spatial skills. It is essential to disseminate an understanding of haptic abilities and that effective instructional activities need not involve expensive technology to positively impact students.

During phase 3 we will conduct a detailed analysis of the test results to determine if there is any difference in three groups – the overall population of neurotypical adults (data already exists), freshman engineering students, and future STEM teachers. The culmination of these three phases will help determine the focus of future research in this area including outreach to increase knowledge of the importance of haptic activities in STEM instruction.

Conclusions

Because of the importance of spatial visualization to academic success in the STEM fields, the importance of haptic activities in developing these abilities, and the seemingly prevalent misunderstandings of how haptic activities can be implemented simply into currently existing instruction, this study aims to reach the population that can have an impact on students before they begin university studies.

Recruiting pre-service teachers to use as subjects has so far proved difficult for multiple reasons. There are no STEM education majors or minors on the researchers' campus, thus any testing will involve travel to another campus. The testing itself requires an approximately 30 minute

time block, including informing the subject of the research protocol, administering the test, then answering any questions so the number of subjects tested in a day is limited, even with two people currently trained in administering the test. Anyone who works with pre-service teachers and would be interested in having their students participate in this study should contact the author.

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