The Visual Test of Science Identity (VTSI)

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Abstract: In science identity perception research, there is a need for tests that can estimate student beliefs without presenting a reading burden for young students and low-proficiency readers. We respond to this challenge by developing a visual assessment, employing photos to query opinions about scientists' gender and ethnicity/race. In two samples, adults (n=162) and children (n=42), we found a bias: males chose images of men more than females chose women. Future directions are discussed.

Introduction

Young students' perceptions of themselves and others as scientists impact the coursework they might later choose in secondary school and higher education. In particular, female students and students of color often stay away from the natural sciences (National Science Foundation, 2017). This imbalance has compelled the US Institute of Educational Sciences (IES) to prioritize investigating methods by which to change this trend and encourage students traditionally underrepresented in STEM disciplines to consider pursuing those areas (Chen, 2013). It is also widely recognized that K-12 education must support students to gain vital STEM competencies and to develop a sense of self-efficacy in learning and reasoning within STEM domains (Collins & Halverson, 2009). To support the engagement of students in STEM fields, we require not only assessments of students' understanding of the nature of those disciplines, but also assessments of students' STEM identity (Stets, Brenner, Burke, & Serpe, 2017; Taconis & Kessels, 2009). Toward building capacity to make changes in demographic underrepresentation among scientists, this report describes our development and evaluation of an instrument, the Visual Test of Science Identity (VTSI), designed to measure students' identity in science using a visual modality. Using less verbiage than traditional verbal-modality assessments, the visual modality can open participation opportunities for younger students (Chambers, 1983; Losh, Wilke, & Pop, 2008; Walls, 2012) and for low-proficiency readers of the assessment language, as well as lessening potential linguistic and cultural biases (Creswell & Miller, 2000; Guba, 1981).

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Visual assessments hold great promise, as they can potentially reveal student thinking with low linguistic demands. A visual mode of querying has also been useful in breaking up typical language-based modes of assessment (Walls, 2012). Further, incorporating visuals in assessments can decrease construct irrelevant variance by maintaining students' interest when they might otherwise have felt the assessment to be too lengthy.

While previous work in visual assessments has been limited, there have been efforts that offer suggestions for our development of image-based survey items. In the Draw a Scientist Test (DAST; Chambers, 1983), for example, students who were asked to draw a scientist often drew iconography associated with prototypical scientists (Chambers, 1983; Losh et al., 2008; Walls, 2012) – perhaps because iconography is what students thought the people testing them would recognize (Reinisch et al., 2017) – and did so to the extent that Losh et al. (2008) believed that the DAST assessed stereotypes. Walls' (2012) Identify a Scientist (IAS) tool addressed the Nature of Science concurrently with science identity by asking students to choose one person among groups of gender- and ethnicity-balanced photos who they thought was a scientist, revealing a student preference for science iconography (e.g., 96% of students believed scientists wore glasses). Chapman and Feldman (2017) obtained mixed results when using the IAS task to gauge differences in perceptions about who can be a scientist before and after an inspirational intervention led by a female scientist. After the intervention, more students selected their own demographic as the scientist, but fewer selected women. Recently, Reinisch and colleagues (2017) called for the development of closed-ended testing solutions to remove threats to validity.

Method: Instrument development, sample, and results

The VTSI was developed to build on Walls' (2012) IAS design in a manner that excluded science iconography from the interpretation of results, leaving gender and ethnicity/race. Like the IAS, photographs were collected for the 10 categories of the fully crossed factors of gender (at two levels: male, female) × ethnicity/race (at five levels: Black, White, Latinx, East Asian, South Asian). The VTSI further categorizes photographs to enable the construction of 10-photo panels that control for science iconography, e.g., differences in lighting, subjects' ages,

eyeglasses, formality of attire, and males' facial hair. Presented with a panel of 10 photographs, participants were asked to identify which person was most likely to be a scientist and the degree to which they thought each person was a scientist. Multiple panels were administered to support reliably interpreting results.

Two samples were collected. A pilot study was performed on adults to test the VTSI for flaws before use on the higher-stakes sample of interest, children. We recruited 154 adults (male=80, female =74), of whom 65% were White ethnicity/race. No changes were needed after the VTSI pilot. Next, 41 middle- and secondary-school students (male=29, female=12) were recruited from demographics underrepresented in science as part of an existing after-school program, with an ethnic composition of 17 Black, 19 Latinx, 1 White, and 4 students of other ethnicities. The analysis of both the adult and student samples was conducted using McNemar's test for related nominal groups to compare the choices made by different gender and ethnicity groups, e.g., women and girls were related to photos of female scientists, and men and boys to photos of male scientists.

Results and discussion

For the adult pilot test, results indicated women were less likely to choose photographs of females as scientists than men were to choose male scientists ($\chi^2 = 9.23$, $p < 0.01$). This result held up for the sample of students, in which girls chose females as scientists less frequently than boys chose men ($\chi^2 = 10.83$, $p < 0.001$).

The efforts to control factors in photos other than gender and ethnicity appeared to have been successful, because when students were taking the VTSI, many expressed not knowing how to choose. When students did choose a photo, the results were still biased in favor of men. However, our study found that students did not appear to disproportionately select White ethnicity/race photos ($\chi^2 = 5.08$, $p = 0.28$). Even so, many students still did not endorse photos of people of their own ethnicity as scientists.

Future validation for the VTSI will ask students the reasons for their photo choices, to ensure that science iconography is not among the reasons. Future developments for the VTSI will continue to leverage the visual mode by incorporating controlled interactions between existing photos of *people*, imagery of *tools* of science, and *settings* in which science is performed. Accompanying interviews would elicit students' beliefs as to what the people depicted in photographs would do with the tools in the settings depicted.

In this work, a practical tool with many potential applications has been developed for the measurement of beliefs held by people of many ages – young children through adults – concerning who is a scientist; by removing traditional "science" iconography, gender and ethnicity/race remained to elicit responses. This method can be easily ported to other fields where similar questions are being asked.

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