CS Education and Engineering Education: Joint Research to Develop Students' Interest and Success

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In the current wave of the national STEM Education debate, two fields are emerging with growing calls for a (1) stronger presence in pre-college education and (2) basing design, curriculum and teacher preparation on stronger evidence-based empirical models: Computer Science (CS) and Engineering (E) Education.

This whitepaper lays out common ground for both arguing that joint research efforts might advance both movements’ agenda; and presents four clusters of joint research questions.

Several different lenses can demonstrate the similarities between CS and E: Both fields are underrepresented in the K-12 space, CS as the only STEM field with a decrease in student participation in the last years and engineering trailing with single digits all participation rates in other academic subjects (Nord, Roey, Perkins, Lyons, Lemanski, Brown & Schunknecht, 2011). More substantively, CS and E are both engaged in their core in “creating a world that has never been” (Theodore von Kármán) by making things that do not exist in nature. Both share that their work is often perceived as very technical and cold and yet, the work is deeply artistic as in “elegant code” (Dongarra & Luszczek, 2007), “aesthetic computing” (Fishwick, 2002) and engineering design as an art form (Atman, Eris, McDonnell, Cardella & Borgford-Parnell, 2014).

The following presents three different education research areas, which can move both CS education and E education forward:

(1) Learning Progressions (LPs) in CS and E

LPs, as defined by the National Research Council (2007) are descriptions of how content and practices are organized from least complex to most complex relative to the ways students acquire expertise, and thus reflect the development of competence across developmental and grade levels. Compared to research in natural science education on LPs, (Corcoran, Mosher & Rogat, 2009; Duncan & Rivet, 2013), research on LPs in CS and E is scarce to nonexistent. Understanding developmental and age differences in thinking and acting of CS and E would not only provide us more insight into students’, research may inform instructional design and teaching practices.

Sample research questions include:
How do thinking and acting like a Computer scientist or an Engineer manifest themselves across different developmental and grade levels?
Which are age and developmental appropriate (a) terminology and (b) practices to foster sustained interest in CS and E?

(2) The role of magical thinking in the development CS and E thinking

As Arthur C. Clarke states “Any sufficiently advanced technology is indistinguishable from magic” (1962, p.26). Until very recently the scientific community saw magical and
scientific reasoning as two ends of a developmental process, in which the objective of education was seen to develop scientific thinking and to overcome magical reasoning. In fact, computers, software and engineering share that the work and the products are often perceived as “hidden” and “magic” (Papert, 1996) and a distinctive goal of CS/E education can be seen to take the magic out of CS/E, to move the hidden into the open, open the black box and showcase that the “magic” is not magic at all. The position of the magical as something to overcome was challenged by research and conceptual development in educational psychology (Rosengren et al., 2000; Rosengren & French, 2013), in which magical reasoning is defined as “(1) to realize that objects and events in the world generally follow a certain pattern or order; (2) realize that the observed object or event in some way […] “contradicts” the normal order of things in the world; and (3) hold a belief in some form of supernatural or alternative form of causality that extends beyond those that govern the natural world” (Rosengren & French, 2013). Practice in analytics, data mining and “big data” is concerned about the detection of patterns in large data sets and relies on the imagination and creativity to not only develop code, but the curiosity to follow emerging patterns with systematic procedures. Research is needed to understand the relationship of magical reasoning and CS/E and the roles of imaginative thinking on the development of interest and competence in CS/E.

Sample research question include:

Do children with higher levels of magical reasoning showcase higher levels of computational thinking as it relates to pattern recognition and questioning status quo in approaches to solving common persistent problems?

(3) Engendered roles of technologies and roles of human beings in CS/E

Following initial observations on sex distributions of technology education faculty, we conducted systematic research revealing that 87% of Technology Education faculty were male compared to only 53% of faculty in Educational Technology. Similarly Technology Education employed a significantly lower number of female full professors and an uneven gender distribution amongst their faculty ranks (overly assistant professor rank). This came to a surprise as a curriculum analysis additionally demonstrated that the technical and statistical requirements of the two fields did not show any significant differences. So, why the massive difference in sex distribution? There are several different possible answers including the different historical roots of the discipline and the associated workforce. A possible answer we provide is that the role of technology is differently conceptualized in both fields: In Technology Education, technology is conceptualized as a goal in itself while in Educational Technology, technology is conceptualized as a means to an end in support of “something else”, in this case learning (Strobel, Tillberg & Rui, 2010). As fields we need to deeper and more fully understand of what Sherry Turkle (1984) calls “Loving the Machine for Itself” and its role for students to choose or not choose to study CS/E and perceive CS/E as viable and desirable professions.

Sample research questions include:

To what degree do perceptions of CS/E as “love of the machine for itself” influence girls’ development of interest and decisions on pursuing CS/E careers?
References