PROJECT SUMMARY

Computational thinking and creative thinking are two core competencies which are essential for both STEM and non-STEM students. **Computational thinking** is vital to today's education to better equip our students with the competitive skills to do well in today's increasingly data-intensive and digital industries (cf. Rising above the Gathering Storm, 2007) and is a skill as fundamental as reading, writing, and arithmetic to every child's analytical ability (Wing 2006). In the way that computational thinking is not just for computer scientists, but for everyone, **creative thinking** should be an essential aspect of any problem solving process. Creative thinking, as evidenced by the work of experts in many fields, is not an innate talent or the province of just a few individuals, and it is not confined to the arts. Rather, it is a process which is an integral component of human intelligence, which can be exercised within any context and which can be practiced, encouraged and developed (Epstein 1996; Epstein *et al.* 2008; Shell *et al.* 2010). By combining these two core competencies, they can be delivered together more efficiently, more effectively and with greater appeal to students. Combining computational thinking with creative thinking strengthens STEM disciplines by expanding students' ability to solve complex, ill-defined and interdisciplinary problems by broadening students' thinking and helping them break perceived constraints.

Our ***long term vision*** is to incorporate computational thinking and creative thinking into undergraduate STEM courses to better prepare students to be flexible and resourceful problem solvers, interdisciplinary collaborators, and skilled practitioners of both logic and creativity. The specific objectives of this proposal, called **Integrated Computational and Creative Thinking (IC2Think)**, are to (1) adopt and extend the existing suite of online learning objects on introductory computer science (CS1) computational thinking topics by aligning the concepts to creative thinking activities; (2) design and develop a set of creative thinking exercises for in-situ activities (either in class or lab) with CS1 computational thinking alignment; (3) Deploy these learning objects and exercises as integrated modules in NSF CPATH-funded Renaissance Computing courses; and (4) evaluate the impact of these courses on students' computational thinking and creative thinking,as well as their motivation and self-regulation concerning STEM and their specific discipline.

Broader Impacts. The IC2Think project will improve STEM education in STEM (and also non-STEM) disciplines. In contrast to stand-alone courses, our individual lesson modules are more "user friendly"—i.e., accessible to a broader audience of students from many disciplines and easier to adopt by instructors and faculty in a variety of classroom and distance settings. When used with STEM students and faculty, we can promote computational thinking primarily as an enabling problem solving approach and creative thinking as an enriching problem solving approach. Research studies and results of our investigation and evaluation will give us valuable insights into the approach's effectiveness and reported in academic venues. Tangible products such as the lesson modules will be used and disseminated campus-wide through Renaissance Computing, nationally through the existing NSF BPC, CPATH, and future TUES communities, locally through outreach to school teachers and archived online as well. Both our dissemination activities and the content of the modules themselves will help increase participation by females and other underrepresented groups in computing due to the modules' inherent appeal.

Intellectual Merit. First, our approach is grounded on two fundamental problem solving concepts—computational thinking and creative thinking—and how best to coalesce these two core competencies seamlessly into STEM and non-STEM subjects and disciplines. Second, the development and validation of the lesson modules is based on sound design-based research methodology while the educational impact evaluation is grounded in sound educational theories and frameworks. Finally, our proposed activities leverage off successful, on-going NSF projects (i.e., Renaissance Computing and the CS1 courses, and iLOG and the learning objects and software infrastructure) and existing partnerships and initiatives. Thus we are uniquely and strategically positioned to execute the proposed activities. Our team is interdisciplinary and has participated in Renaissance Computing and numerous interdisciplinary education and curricular initiatives. Also, because the proposed activities will be relatively cost-effective to sustain after the funding period ends, our project will have a positive long-term impact on campus.