CS 10K: Computer Science Student and Teacher Education Pathways (CS-STEP)

Project Overview

Computer science education in K-12 lies at a critical intersection between meeting the grand goal of computing for all and building the capacity to provide meaningful educational computing experiences (Wilson & Guzdial, 2010). A number of initiatives have targeted the need to recruit a wide range of learners into CS fields during their K-12 experiences (Walker, 2012). Some of these initiatives have involved working with high school teachers through mentoring initiatives or workshops (Cuny, 2011; Walker), while others have focused on direct contact with high school students through robotics road shows or computing summer camps (e.g., Martin et al., 2011). However, the biggest challenge is not the curriculum, but in effective teacher development and supports that are scalable to prepare enough computing teachers to address this national need (Cuny, 2011). In other words, we need documented common practices that inform the implementation and sustainability, and address the four persistent questions:

1. How do we effectively prepare practicing teachers for computing education?
2. What are the teacher pathways toward successful computing education?
3. How do we support the work and professional identity of computing teachers?
4. How do we cultivate new paths that intersect with students on parallel or diverging paths?

In order to understand how to best target and sustain CS education initiatives, we propose the ***Computer Science Student and Teacher Education Pathways*** **(CS-STEP)** project. Our initiative targets the above questions in the context of four elements: (1) a 15-credit hour teacher certification program leading to the Indiana Computer Education License, (2) a Dual Enrollment high school version of an undergraduate computing course piloted in 16 Indiana high schools, (3) a teacher community of practice designed to support instructional efforts and professional identity, and (4) a systematic recruitment plan that intersects with existing student interests outside of but related to CS (i.e., art, music, media studies, and the like). Thus, *the **intellectual merit** of this project is reflected in the rigorous investigation of the ways in which we cultivate teacher pedagogical CS knowledge and professional identity, while simultaneously recruiting learners and sustaining their interest in CS.* Drawing from previous research on teacher professional development, collaborative action research, communities of practice, and broadening participation, we will identify critical activities that support teacher transformation, sustain teacher involvement, and cultivate the interests of a wide range of learners.

Furthermore, CS-STEP will yield several important ***broader impacts***. The project design leads naturally to the *integration of research and education*. The central foci of the project involve leveraging the following: existing pathways (Indiana Computer Education License; a thriving Dual Enrollment program), conducting research related to the development of teachers, and establishing a cohort of secondary CS teachers capable of teaching university-level courses at their high schools. The project addresses *participation of underrepresented groups* by partnering with schools that serve underrepresented student populations (urban in central Indiana; rural in central and southern Indiana). The *infrastructure for research and education will be enhanced because the project cultivates a new network of CS education teacher-scholars* that spans a variety of settings. The resultant network brings together computer scientists, teacher educators, and teachers in partnering schools. In addition to this network, the curricula and outcomes disseminated to support CS education will foster new capacities for teachers and students to engage in personally relevant CS practices through intersecting pathways.

Context

Why is high school computing important? Computing provides a foundation for science and industry and is one of the fastest growing occupations in the U.S. (Groth & MacKie-Mason, 2010). However, according to the Bureau of Labor Statistics (BLS), the inability to fill all of the technology-based positions has created a high-tech worker market (BLS, 2013). Furthermore, National Center for Educational Statistics' National Report Card (2009) stated that computer science remains the only STEM field that has seen a decline in student participation at the high school level in the past two decades. If we are to build a globally competitive 21st century workforce and maintain our national leadership in IT innovation, there is no stage in the academic pipeline more crucial than high school (Cuny, 2009). Since 2000, the percentage of incoming college freshmen in the U.S. who intend to major in computing has decreased more than 70 percent overall and 80 percent for women (Pryor et al., 2007). In 2011, a national survey of new college freshmen shows an even further decline, with just two percent of students intending to major in computing (Pryor et al., 2012). In other words, we are not graduating enough computer scientists in the U. S. to meet the needs of the workforce (Wilson et al., 2010).

Students often have little exposure to CS prior to college, and what exposure they do have may leave them inadequately prepared for college-level study of the discipline. A recent national survey by the Computer Science Teachers Association (CSTA) found that in 2009 only 65 percent of secondary schools in the U. S. offered a computer science course and only 27 percent of schools offered a Computer Science Advanced Placement (CS AP) course. In addition, only 15,000 high school students take the CS AP exam annually. Nationally, there are just 2,000 teachers qualified to teach the Computer Science AP course. The CS AP course is not optimal; it is programming-centric, it is inaccessible to students with no prior experience, it does not focus on the fundamental concepts of computer science or computational thinking, and it does little to teach the breadth of application or beauty of computing (Guzdial, 2009). In short, the pathway into computer science is narrow and serves too few students (Cuny, 2011).

How informatics can help. All current and future students entering high school have grown up in a world where computing is commonplace; many of them are less interested in how computing works than in how to utilize computing to solve specific problems in other domains of human knowledge. As previously mentioned, there is a high need for computer scientists and informatics can provide a complementary path to reach these students (Groth & MacKie-Mason, 2010). Therefore, using an informatics gateway that incorporates the Exploring CS curriculum may provide a relevant context of CS, capture students with diverging interests (i.e., art, music, media studies, and similar), and motivate them to pursue CS degrees in college (Guzdial, 2009).

The local need: Indiana. Similar to the rest of the country, there is very low interest in computing majors in college in the state of Indiana. In most Indiana high schools, computing courses are taught by business teachers and involve very basic computing literacy topics. Although Indiana has a teacher license in computer education, only four higher education institutions offer a CS teacher preparation program (IU, Purdue, Indiana State, & Ball State). Currently, the only program that includes strong computer science requirements is Purdue. Indiana State, Ball State, and Indiana University currently address computer applications and media design, as opposed to computational thinking and programming skills. Furthermore, these programs tend to be small, graduating fewer than ten students each year. Out of all four institutions, only two require a field placement to receive the licensure (Indiana University and Purdue). Overall, the state of Indiana needs to expand programs and create pathways for computer science education.

Addressing the Challenges: Project Description

The pathways that foster entrance into computer science are not robust enough to support a wide range of learners with diverse interests. In addition, success for a wide range of learners hinges on high school teachers who can teach, inspire, and mentor. With these goals in mind, the Indiana University (IU) School of Education in partnership with the IU School of Informatics and Computing propose the CS-STEP project. In collaboration with Indiana high schools, we propose to develop and implement (1) a 15-credit hour teacher certification program leading to the Indiana Computer Education License (CEL), (2) a teacher community of practice designed to support instructional efforts and professional identity, (3) a Dual Enrollment high school version of an undergraduate computing course piloted in 16 Indiana high schools, and (4) a systematic recruitment plan that intersects with existing student interests outside of, but related to, CS (i.e., art, music, digital media or similar). Our project addresses four persistent questions in CS education:

1. How do we effectively prepare practicing teachers for computing education?
2. What are the teacher pathways toward successful computing education?
3. How do we support the work and professional identity of computing teachers?
4. How do we cultivate new pathways to intersect with students on parallel or diverging paths?

Project Strands and Activities

To enable successful opportunities in computer science for a wide range of high school students our project will consist of six key elements divided across three strands:

Strand 1: Planning: Program, Curriculum, & Teacher Recruitment (Year 1)

1. ***Transform existing CEL program*** at IU to align with CSTA standards.
2. ***Redesign the Informatics 101*** (I101) course for the Dual Enrollment HS experience (e.g., accommodate block scheduling, incorporate robotics element, align with Exploring CS).
3. ***Recruit teachers*** (eight in Cohort 1; eight in Cohort 2). Tuition will be paid by the grant.

Strand 2: Implementing: CEL Program and HS Dual Enrollment Path (Years 2 & 3)

1. ***Institute CEL (Two cohorts of eight teachers each).*** During the first summer of the program, teachers will enroll in three hybrid (online and face-to-face) courses. During the following academic year, they will enroll in a methods course and practicum.
2. ***Implement Summer Institute.*** IU Informatics faculty will conduct a 5-day intensive, residential teacher training during the summer in preparation for the Dual Enrollment I101 course. The IU faculty will serve as ongoing mentors for the teachers.
3. ***Recruit students.*** Teachers will work to develop a strategic recruitment plan in collaboration with IU faculty for the I101 DE course. The first cohort of teachers will offer the course in Year 2 to 160 students; the first and second cohorts of teachers will offer the course in Year 3 to 360 students. Course student fees will be paid by the grant.
4. ***Implement Dual Enrollment (DE) path.*** The DE course will be taught in collaboration with IU faculty from the School of Informatics and Computing, who will deliver the lecture via video. The faculty will help supervise and mentor the teachers as they implement the labs in their own high schools. The teachers will be responsible for supplemental teaching, lab instruction, and student grading.

Strand 3: Capturing and Sustaining (End of Teacher Cohort Experience in Years 2 & 3)

5. ***Implement Collaborative Action Research projects.*** The Collaborative Action Research approach fosters teacher growth and transformation, especially in fields with complex content. The outcomes of their projects will inform best practices for CS education.

6. ***Build a Community of Practice.*** To help implement the Dual Enrollment I101 course in high schools, an online community of practice support system will be developed to encourage the exchange of curricular materials, facilitation of questions by experts, and collaborative problem solving by the high school teachers.

Strand 1: Planning: Program, Curriculum, & Recruitment (Year 1)

Revisions: Computer Education Licensure Program. In the state of Indiana, the computer education license certifies teachers to teach both computer applications and computer science courses. The CEL offered through IU is a 15-credit-hour program (five courses) that meets requirements for the Indiana Computer Education License. The CEL program currently addresses both strands for licensure defined by the International Society for Technology in Education (ISTE): National Educational Technology Standards for Coaches (NETS-C) and Computer Science Educators (NETS-CSE). However, based on a review of our curriculum (with assistance from our Advisory Board member Mark Guzdial), we have identified a stronger need to address the CSTA standards.

Each year, teachers will progress through the courses in cohorts. The first three classes occur during summer. The fourth and fifth courses occur during the following academic year. The current CEL program focuses on the NETS for Coaches and lacks significant coverage of the CSTA standards. The revised program will improve teacher preparation of CS content knowledge, as well as methods for teaching CS (see Tables 1 & 2).

Table 1. Current and Revised CEL Programs.

Current CEL Program		Revised CEL Program	
R511: Instructional Technology Foundations	Introduction to the field, theory, and profession of instructional technology	R531: Computers and Education	Introduction to computational thinking and effective use of computer applications
R505a: Leadership Issues in Ed. Tech.	Issues encountered by tech leadership (tech management, grants, staff development)	R505: Leadership Issues in Ed. Tech.	Computational thinking, computer science in the modern world, and ethical and issues for leadership
R547: Computer-Mediated Learning	Develop instructional project utilizing the Web (e-learning)	R520: Technical Issues in Computer Based Ed.	Introduction to computer hardware, software, and programming concepts[1]
R505b: Computer Based Teaching Methods	Methods of teaching computer literacy, computing skills, and programming at K-12	W540: Computer Based Teaching Methods	Methods of teaching computer literacy, computing skills, and programming at K-12
R586: Practicum in Instructional Systems Technology	Develop, implement, and evaluate semester-long technology integration project	R586: Practicum in Instructional Systems Technology	Implement I101 and Teacher Action Research project

[1] This includes the five-day training for the Dual Enrollment course, I101.

Table 2. Mapping for NETS and CSTA Standards Alignment.

Standard	**Current Program**	**Revised Program**
NETS for Coaches		
1. Visionary leadership	R505a; R586	R505
2. Teaching, learning, & assessments	R511; R505b; R586	R531
3. Digital age learning environments	R547; R586	W540
4. Professional development & program evaluation	R586	R505
5. Digital citizenship	R505a; R586	R531
6. Content knowledge professional growth	R586	R531
NETS for Computer Science Educators		
1. Knowledge of content	--	(all courses)
2. Effective teaching and learning strategies	R505b	W540
3. Effective learning environments	R547	W540
4. Effective professional knowledge and skills	--	R586
CSTA Standards		
Level 1: Computer Science and Me	--	R531
Level 2: Computer Science and Community	--	R505
Level 3a: Computer Science in the Modern World	--	R520
Level 3b: Computer Science Concepts and Practices	--	R520
Level 3c: Topics in Computer Science		
Web Development	R547	R505
Multimedia	R547	R531
Graphics	R505a	R531
Desktop Publishing	R505b	R531

Revision of I101 for Dual Enrollment. The Dual Enrollment course *Introduction to Informatics and Computing* (I101) serves as an entry point to foster greater high school participation in additional computing experiences. *Introduction to Informatics and Computing* (a four-credit hour course) provides a hands-on approach to understanding and using technology. I101 counts towards the bachelor’s degree in Informatics or Computer Science. By the end of the course, students are expected to transform data into actionable knowledge, explain different parts of technology, and critique the impact of technology on society/culture. Furthermore, students must apply critical thinking, logic, and computational tools to solve authentic problems.

I101 has a weekly structure of one lecture and two labs. Labs consist of hands-on activities (programming, design) while lectures utilize class discussion and activities surrounding larger concepts and theory. The length and chunking of both the lecture and lab components will be revised to fit the block scheduling requirements of high school. Both lectures and labs incorporate active learning techniques (e.g., Team-Based Learning, Pair Programming).

The lectures would be recorded online by IU Informatics faculty for use in the high school dual enrollment course. Lecture assignments include weekly readings and reflection papers while lab assignments encompass primarily hands-on assignments.

Revision of I101 to meet Exploring CS Competencies. I101 (Table 3) aligns with the stated learning outcomes outlined in the Exploring CS Curriculum. In addition, teachers could draw on additional materials from the CS 10K online community.

Table 3. Alignment between Exploring CS Curriculum and I101.

Exploring CS	I101
ECS Topic 1 - Human Computer Interaction	1wk. Topics: form, function, design, first-third wave schools of thought, affordances, intuitive design, contextual design, design impact
ECS Topic 2 - Problem Solving	3 wks. Topics: problem solving structures, methods to identify specific problems, nature of problems (wicked/tame), logical/critical thinking, add structure to problem solving, common problem solving mistakes.
ECS Topic 3 - Web Design	2 wks. Topics: HTML, CSS, create webpages, mini project, final personal web portfolio/website, final group project using web design.
ECS Topic 4 – Programming	3 wks. Topics: JES (media computation tool uses Python), pseudocode, basic definitions (algorithms, functions), writing basic functions, loops
ECS Topic 5 - Computing and Data Analysis	3 wks. Topics: data mining, information hierarchy, KDD, visualization, use SQL to build, populate, and query data.
ECS Topic 6 – Robotics	Not currently cover in I101 but will be incorporated into the Dual Enrollment version. Project supplies for robotics kits.

Revisions. Once the curriculum for the dual enrollment I101 course has been revised, the draft syllabi will be submitted to the Advisory Board in early spring 2014. Based on feedback, the curriculum will be revised and presented to the Advisory Board during the spring 2014 face-to-face meeting. Final suggestions and revisions will be made over the spring before the first implementation of the CEL courses with the first cohort of high school teachers in summer 2014.

Teacher Recruitment. To ensure the successful implementation of computing courses in Indiana, we will partner with a local district (Monroe County Community School Corporation) and two state consortiums (Southern Indiana Career and Technical Center; Central Indiana Educational Service Center) to identify partner schools and teachers. This strategy is particularly effective as it recruits teachers from within a school system that is supportive of expanding CS opportunities for students. To gauge effectiveness with a wide-range of students, we will specifically recruit teachers with potential to serve economically and racially diverse learners. For example, we will prioritize teachers who serve as coaches, activity sponsors, or program directors. The selected teachers can be previously certified in any subject area. Each selected teacher will implement I101 at least once during the academic year. The course could be offered at the same high school during different semesters if there is enough interest from students.

Strand 2: Implementing: CEL Program and HS Dual Enrollment Path (Years 2 & 3)

Revised CEL Implementation. Our partner high schools will make a commitment to offer the I101 dual enrollment course at least once per year. In Year 2, eight teachers will participate (cohort 1) and in Year 3 eight additional teachers will participate (cohort 2). During the summer of the CEL program, the teachers will complete three courses (R531, R505, W520) taught primarily online with a one-week face-to-face institute on the IU campus. During the following academic year, teachers will enroll in the last two online courses (W540, R586) focused on CS methods and a practicum. All tuition costs for the CEL program will be covered by the grant. Also during this semester, teachers will be asked to plan a teacher action research project. In the following spring, the teachers will implement the Dual Enrollment I101 course in their high schools. They will also conduct their teacher action research project on the course. An online community of practice support system (described below) will provide a space for teachers to interact with each other, ask the I101 instructors and experts for feedback or clarity, and provide feedback on the I101 lab implementation and materials.

Advance College Project and Dual Enrollment. The IU Advance College Project (ACP) allows high school teachers to teach college level courses in their own high schools throughout the state: dual enrollment courses. Upon successful completion of a Dual Enrollment class, high school students receive credit for the high school class *and* they receive college credit from IU for the same class. The ACP of Indiana University is recognized nationally as an exemplar in Dual Enrollment, is a founding member of National Alliance of Concurrent Enrollment Partnerships (NACEP), and has representation on the NACEP board and chair of accreditation. The program serves over 200 high schools in Indiana, enrolling more than 13,000 students.

Reports on dual enrollment programs have indicated strong gains in college attainability and access for participants, especially first-generation and underrepresented minority students (e.g., Adelman, 2006). Multiple studies also report higher first to second year retention rates, higher first-year GPA's, greater credit accumulation, and increased likelihood of postsecondary enrollment (Ganzert, 2012; Hughes, Rodriguez, Edwards, & Belfield, 2012; Struhl & Vargas, 2012; Swanson, 2010). Further, gaining college credit prior to matriculation may also reduce overall costs of attendance. Dual enrollment is most effective when structured within a clearly articulated degree; disciplines such as computing and CS are particularly suited to dual enrollment based on the well-defined curricular pathways.

Currently, the CS dual enrollment opportunities in Indiana are derived from career and technology education delivered through community colleges. The I101 course would be a valuable addition because it expands the breadth of computing courses currently available and introduces the field of CS through a broader lens than career education.

Student Recruitment. Women and minorities (Black, Hispanic, and Native Americans) continue to be underrepresented in computing (Hill, Corbett, St. Rose, 2010) and enrollment of underrepresented groups in CS programs continue to decline at a significant rate (Clinging, 2006). The students that enroll are overwhelmingly Caucasian or Asian male (Bruckman et al., 2009). The number of women among bachelor's graduates decreased in Computer Science from 13.8 percent in 2010 to 11.7 percent in 2011 (Zweben, 2012). Furthermore, Black students encompassed 4.6 percent of the total bachelor's graduates and Hispanics had a 6.5 percent representation (Zweben). The American Association for the Advancement of Science (AAAS) has stressed the urgency of the situation by releasing a call to action for Congress to establish policies that help increase participation among underrepresented groups in STEM (Nealy, 2007) According to the AAAS, failure to remedy this situation will be harmful to American innovation. The Commission of the Advancement of Women and Minorities in Science, Engineering, and Technology (Lazowska, 1999) made several recommendations to introduce programs to remedy this situation. One recommendation was to offer programs that educate women and minorities about computer science and to recruit them to the field by expanding their exposures to computing in grade school and high school.

This recommendation is actualized in the most important component of our pathways project: our approaches for recruiting a wide-range of learners to extend beyond the usual pathways that attract typical CS students. We will employ a twofold approach: (1) partnering with schools that serve high proportions of Black, rural, and low-income students, and (2) creating opportunities to intersect with students' broad existing interests, such as art, music, digital media, and other activities. In other words, the students we recruit may be on parallel or non-intersecting paths with CS, and we would create opportunities to show how current interests may intersect with CS. Dual enrollment courses have proven particularly beneficial to underrepresented groups of learners. Johnson, Brophy, and Pitre (2006) found that rural students benefited academically and socially from dual enrollment involvement. These results were extended by An (2012), who found that first generation college students with dual enrollment participation were more likely to obtain a college degree than their first-generation counterparts, and the effect is nearly as high as that of AP involvement. This is an important finding because while the pathway to AP participation is dependent upon earlier academic successes, dual enrollment can attract wider student participation. Furthermore, a number of initiatives have demonstrated success at recruitment of diverse learners through school clubs and extracurricular experiences. Cohoon, Cohoon, and Soffa (2011) gave teachers school-wide recruitment strategies for attracting girls and minority learners, and found significant gains in participation. With this in mind, we plan to work with our CS recruiting expert, Dr. Maureen Biggers, and the teachers to develop a systematic recruiting plan. We will recruit 20 students for each teacher's offering, resulting in 160 students served by the first cohort of teachers in Year 2 and 320 students served in Year 3 in by cohorts 1 and 2.

Strand 3: Capturing and Sustaining (End of Teacher Cohort Experience in Years 2 & 3)

Collaborative Action Research. After the summer CEL experience, the teachers will enroll in the last two courses (W540, R586) during the subsequent academic year. These courses will focus on teaching strategies for computer applications and computer science. During this semester, teachers will also be required to plan a teacher action research project in collaboration with their peers. ***Collaborative Action Research*** provides the specific platform for teacher collaboration and transition to sustainability. Within this approach, the researcher (teacher) identifies a problem or question, develops a critical self-study research plan, and systematically collects data in order to arrive at a path of action or deeper understanding regarding the question of inquiry (Capobianco & Joyal, 2008). An important dimension of action research is the purposeful, iterative nature of the work, which has been used at length to help teachers integrate pedagogical and content knowledge. For example, one science educator worked with three high school teachers to understand and articulate the impact that ongoing action research projects have had on their teaching (Capobianco et al., 2006). Each teacher sought different pathways in her approaches to the research, including gaining new knowledge on increasing student confidence in science to inventing curricular approaches when the textbook did not suffice. Furthermore, teachers reported feeling empowered to take risks in their instructional approaches as a result of engaging in action research (Capobianco et al., 2006). Another university science educator echoed this feeling of empowerment in her description of conducting action research projects as a way to understand learning interactions within science classrooms (Marin-Dunlop, 2006). Although action research results in very different experiences, it is consistently described as empowering teachers to transform their practices. Within CS-STEP, teachers will collaborate and develop an action research project to be conducted in Strand 3, which will provide us with a unique lens into their approaches as well as foster their own reflective capacities leading toward transformed and sustained CS practice.

Teacher Community of Practice. Teacher participation in online communities of practice can help teachers with informal learning and emotional sharing (Hur, Brush, & Bonk, 2012).

Successful communities of practice have an "inclusive and mutually supportive group of [teachers] with a collaborative, reflective, and growth-oriented approach toward investigating and learning more about their practices to improve students' learning" (Stoll, 2010, p. 151). Some suggest that such communities can help CS teachers develop their professional identities (Ni & Guzdial, 2011). CS teachers often lack professional identity as there is no typical process to become a CS teacher and most seem to add-on the CS license from a different subject area (math, business) (Ni & Guzdial, 2012). Ni and Guzdial (2012) recommend providing "support for current CS teachers and influence their own sense of identity by creating a community of local CS teachers where they can learn and support each other and change their perception of CS, CS teaching and themselves" (2012, p. 7). Since they are often the only CS teacher in their high schools, the communities of practice within their own buildings are often non-existent.

Therefore, this project will develop a local community of practice focused on the dual enrollment course, I101. Teachers can use this online space to exchange curriculum, pose questions to experts, and discuss best practices as they relate to I101. This project will use the community of practice to examine the best ways to support CS teachers' identity development and increase the commitment of CS teachers (Ni & Guzdial, 2012). To expand beyond the local community, teachers will be encouraged to participate in the national community of practice for CS teachers: the CS 10K Community. Assignments through the CEL program will be integrated into their participation in this online community of practice (Action Research), thus increasing their commitment to the study of CS and solidifying their CS teacher identities (Ni & Guzdial).

Evaluation and Dissemination Plan

The Center for Evaluation and Education Policy (CEEP) will conduct a formative and summative evaluation of the proposed CS-STEP project. As a fully self-funded and independent research and evaluation entity, CEEP has over 50 full-time staff members (including full-time Ph.D. level research scientists, professional and support staff) conducting between 60-80 research and evaluation projects a year, with over $12 million in current research funding. Research and evaluation activities have occurred on the international, national, regional, and local levels, with projects ongoing or recently concluded in all 50 states. CEEP's experience conducting evaluation of science, technology, engineering and mathematics (STEM) programs includes: an Institute of Education Sciences (IES)-funded efficacy study of an online chemistry learning tool; a statewide study of the impact of the Enhancing Education Through Technology (EETT) initiative; and an evaluation of Amgen Foundation's national and international internship program to increase participation in STEM. In addition, CEEP serves as the external evaluator for numerous NSF-funded projects, including the following: a Math Science Partnership-Targeted Partnership; IGERT programs at three different universities; a NSF-funded Scientific Modeling for the Inquiring Teacher Network (SMIT'N); a study of NAEP Mathematics Assessments; a NSF Advanced Technology Education project aimed at improving students' understanding of science and mathematics by developing a culture of collaboration among K-12 schools and higher education; and external evaluations of REESE, RET, DRK-12, NOYCE and ITEST projects funded through NSF.

CEEP's evaluation of CS-STEP will focus on both formative evaluation for purposes of program improvement, as well as summative evaluation to best understand the impact of the program on intended and unintended goals. The evaluation focuses on both the overall impact and effectiveness of CS-STEP when considered holistically, as well as the impact and effectiveness of each of the four key program elements: (1) a Dual Enrollment high school version of an undergraduate computing course piloted in 16 Indiana high schools, (2) a 15-credit hour teacher certification program meeting the requirements for the Indiana Computer Education License, (3) a teacher community of practice designed to support teacher efforts and professional identity, and (4) a systematic recruitment plan that intersects with existing student interests outside of but related to CS. The table below provides an overview of the main features of the evaluation design; and additional details related to the measurement of project objectives and performance measures will be developed in collaboration with the project leadership at the start of CS-STEP. In addition to annual evaluation reports, CEEP will provide real-time formative feedback as data are gathered and analyzed; and will discuss preliminary findings and recommendations with the project team at a minimum of four times per year. Table 4 summarizes the evaluation activities.

Table 4. Key Formative and Summative Evaluation Activities.

Key Evaluation Questions	Primary Methods
Years 1–2: What are the major obstacles and barriers to the effective implementation of the key project activities? To what extent (and in what ways) are these obstacles and barriers effectively addressed to ensure the on-going progress of the project?	• Key stakeholder interviews and/or focus groups (e.g., Advisory Board, management team, curriculum redesign team, Dual Enrollment team, student recruitment team, community of practice team, research team, high school teachers.) • Review of extant documents and materials (e.g., proposal, minutes of meetings) • Review and analyses of formative feedback processes and practices embedded within the project • Web-based surveys
Years 1–3: To what extent, and in what ways, are the project activities associated with each of the four primary program components of high-quality, and implemented in a timely manner?	• Key stakeholder interviews (e.g., Advisory Board, management team, curriculum redesign team, Dual Enrollment team, student recruitment team, community of practice team, research team.) • Review of extant documents and materials (e.g., curriculum, project meeting minutes) • Analysis of benchmark data based on key project objectives and performance measures
Years 2–3: To what extent is CS-STEP effective in its recruitment of a wide range of students into CS fields? To what extent does the recruitment broaden participation of traditionally underrepresented populations?	• Key stakeholder interviews • Teacher interviews • Review of extant documents and materials (e.g., project data, student enrollment data from high schools, CS course offerings) • Student web-based surveys
*Years 1–3:*To what extent, and in what ways, does CS-STEP impact teachers' pedagogical CS knowledge, professional identity, and teachers' practices related to computer education?	• Key stakeholder interviews • Teacher web-based surveys • Teacher interviews and/or focus-groups • Pre-post measures of knowledge, attitudes, and classroom practices (e.g., surveys, observations)

	• Teacher action research projects • Review of communities of practice documentation & materials (including CS 10K)
Years 2–3: What is the impact and effectiveness of CS-STEP in creating and sustaining new pathways to intersect with students on parallel or diverging paths?	• Key stakeholder interviews • Teacher web-based surveys • Teacher interviews and/or focus-groups • Teacher action research projects • Student focus groups • Student web-based surveys
Years 2–3: To what extent are the project outcomes, materials/resources and research findings and products effectively and efficiently disseminated?	• Review of project data and documents (e.g., educational licensure curriculum availability online, number of visits to online website, presentations, manuscript submissions, etc.) • Key stakeholder interviews

Project Outcomes, Dissemination, and Sustainability

Scholarly contributions. We envision a number of scholarly contributions that will emerge from project CS-STEP. First and foremost, one of the difficulties associated with the CS pipeline has been student recruitment, specifically cultivating new pathways for diverse students. We plan on describing both our successful and unsuccessful recruitment strategies, focusing on Informatics as a motivating entry point for students. Furthermore, we plan on examining and evaluating the most effective methods for preparing practicing teachers to become computing educators. By investigating the CEL curriculum and online communities of practices, we can better understand how to support teachers as they develop their CS teacher identities and practices. Through collaborative efforts with teachers on their action research projects, we will also gain local insight into the appeal of CS for a wide range of learners and the strategies it takes to cultivate and sustain their interest. These recommendations will be disseminated on our CS-STEP website as well as to the broader academic community through conference presentations and journal publications.

Teacher enhancement. Our history of working with teachers remains central to the work that we do; we will disseminate both teacher-created curricular materials, as well as all CEL program curriculum and resources through our online community of practice and website. These resources are accessible to any teacher or teacher educator. An added component of this project will be to observe teacher implementation of the I101 course, and provide this information to future HS teachers of I101. Furthermore, the teachers will contribute to and participate in the broader online CS 10K community. This adds to the overall impact of our project as well as to the sustainable nature of our work when these teachers hopefully begin implementing additional CS courses at their high schools as students develop more interest in CS.

Sustainability. Our CS-STEP project features a number of components to be sustained after the funding cycle. Sustaining the Dual Enrollment course will cost $200 per student after the grant, but ACP offers scholarships and aid based on financial need. Because we are focusing on capturing students from within their areas of interests, we will cultivate their interests through I101 with the ultimate goal of greater participation in CS. If there is enough appeal at the school, the CEL teacher will be prepared to develop and offer a follow-up course utilizing the CS

Principles curriculum or elective topics on web development, multimedia, graphics, and desktop publishing. We will also make sure the teachers can advise additional courses for students interested in advanced or AP CS; if they are not locally available, these courses are currently offered online and tuition-free through the Indiana Virtual School.

After two cohorts of teachers have participated in the IU CEL program, we feel confident in our capacity to sustain this program. Our immediate strategy will be to reach out to teachers who have the state licensure, and offer them the opportunity to meet the requirements of teaching the Dual Enrollment version of I101 by taking R520 and other courses we deem relevant to boosting their computing knowledge. Furthermore, we will reach out to districts without qualified CEL teachers, ask them to identify potential teachers, as well as offer some resources or support to obtain the licensure. Finally, we plan to crosslist the revised CEL courses with our undergraduate offerings and recruit into the CEL program from among our preservice teachers.

Partnership Plan

The CS-STEP Project will have three core groups focusing concurrently on specific project activities. These groups include: the **management team**, the **curriculum redesign team**, the **Dual Enrollment** team, the **student recruitment** team, the **community of practice team**, and the **research team**. The management structure of the project emphasizes central coordination with collaborative control. Each work group will have unique responsibilities, but all members will collaborate to ensure that the goals of the project are successfully attained. Both the high school teachers and the **project advisory board** will give input into all aspects of the project. An overview of advisory board members is provided in Table 5. The core members and responsibilities of each team are detailed below.

Table 5. CS-STEP project advisory board.

Advisory Member	Title and Affiliation	Background
Dr. Laurie Brantley-Dias	Associate Professor of Instructional Technology, Georgia State University	Expert in technology in K-12 settings, design and development of meaningful learning environments, and teacher development
Dr. Mark Guzdial	Professor of Computing, Georgia Institute of Technology	Content expert in the area of computer science education
Dr. George Veletsianos	Assistant Professor of Learning Technologies, University of Texas	Expert in emerging technologies and hybrid online learning
Dr. Elsa Villa	Co-Director of Center for Research in Engineering and Technology Education, University of Texas at El Paso	Expert in recruitment of students for STEM, computer science content, and teacher transformation efforts

Qualifications of Key Personnel

Dr. Anne Ottenbreit-Leftwich, an assistant professor of Instructional Systems Technology at IU, will serve as principal investigator for the project and have primary responsibility for leading the project management team, directing the research plan, and facilitating design and development of curriculum resources. Dr. Ottenbreit-Leftwich's expertise lies in the areas of the design of digital resources, and implementation of teacher professional development. The online teacher technology curriculum designed by Dr. Leftwich has been downloaded over 248,000 times in 2012. As the current director of the CEL program, she organizes and develops the curriculum for the CEL program. Dr. Ottenbreit-Leftwich has experience working on large-scale funded projects, including one project supported by the U.S. Department of Education for $3.1 million dollars.

Dr. Krista Glazewski, an associate professor of Instructional Systems Technology at IU, will serve as a co-principal investigator for the project, serve on the management, curriculum redesign, student recruitment, and community of practice teams. She will have primary responsibility for overseeing implementation of teacher action research activities, assisting with curriculum reform (specifically targeting teacher scaffolding of students in complex areas), and disseminating of project findings. Her research examines the use of technology to support student inquiry and problem solving. As a teacher educator, she explores means of supporting teachers as they adopt new technological and curricular innovations. She has been a part of leading or directing three large-scale university / school / community partnerships (each funded at upwards of $1.5 million).

Dr. Thomas Brush is the Barbara B. Jacobs Chair in Education and Technology at the School of Education at IU. Dr. Brush will serve as a co-principal investigator for the project, serve on the management and curriculum redesign teams, and play a key role on the implementation of the research plan. Dr. Brush's research interests focus on developing methods and strategies to promote effective use of technology in K-12 settings, and method for best preparing current and future teachers to integrate technology into their teaching. Dr. Brush has over 15 years of experience leading research projects in these areas, and has authored or coauthored more than 50 publications related to these interests. Dr. Brush has extensive experience as a principal investigator or co-principal investigator for over a half-dozen competitively-funded projects, including a $1.15 million *Preparing Tomorrow's Teachers to Use Technology* grant, $750,000 and a $500,000 grants from the Fund for the Improvement of Post-Secondary Education (FIPSE) focusing on improved teaching practices in higher education, and a $1 million *Teaching American History* grant. Dr. Brush is currently leading a project to develop and disseminate a database of wise practice video cases of teaching.

Dr. Dennis Groth will serve as co-principal investigator. He serves as an associate professor of informatics and the Associate Dean for Undergraduate Studies for the School of Informatics. His research focuses on the development of new database access and data mining techniques in support of data visualization activities. As the supervisor for the I101 Informatics Dual Enrollment Course, Dean Groth's role in the grant will be to manage the university instructors teaching the DE course, and serve as an expert supporting high school teachers with questions about the I101 curriculum. Dean Groth will also oversee the curriculum revisions and assist with the student recruitment initiative.

Dr. Maureen Biggers will serve as Senior Personnel for CS-STEP. She is the Assistant Dean for Diversity and Education for IU's School of Informatics and Computing. Dean Biggers has served as co-PI for the Alliance for the Advancement of African-American Researchers in Computing, co-Chair of the Academic Alliance for the National Center for Women in Information Technology, and the Chair of the Indiana Aspiration in Computing 2011 for HS girls. She has been a co-PI on several other grants, including STARS, Georgia Computes!, Increasing Representation of Undergraduate Women and Minorities in CS, and Extending Contextualized

Computing in Multiple Institutions Using Threads. Her research focuses on peer led team learning to improve success and retention in CS classes and CS majors. She was the founding Vice President of the Computer Science Teacher's Association. Dean Biggers will primarily be in charge of the recruitment strategy for high school students.

Nina Onesti is the lead lecturer for the I101 course. She has an M.S. in Human-Computing Interaction Design from Indiana University. Ms. Onesti's will be the primary organizer of the lectures and curriculum for the Dual Enrollment course (I101). In addition, she will serve as an expert to assist high school teachers with the implementation of I101; she will provide additional guidance through the online community of practice support system. Since she served as a Women in Informatics and Computing Steering Committee Member and was the co-coordinator of the SoIC Computing Faculty Collegium on Student Retention and Success, she can also advise the high school teachers on student recruitment.

Dan Richert is a lecturer for the I101 course. He has an M.S. in Human-Computer Interaction Design from Indiana University and a B.S. in Computer Information Systems. He currently teaches two courses, I101 (Introduction to Informatics) and I308 (Information Representation). Mr. Richert was an IT professional in software development for about 20 years. During this time he progressed from a programmer analyst, to manager, to executive and consulting. Mr. Richert will assist Mrs. Onesti with the lectures and curriculum refinement, as well as supporting high school teachers with the implementation of the labs through the online community of practice support system.

Project Management and Timeline

Management team (Leftwich, Glazewski, Brush, Groth). The management team will oversee all aspects of the project and ensure that project goals are being met and that the research plan is being effectively implemented. The management team will work closely with the advisory board and participating teachers to ensure that both the research plan and the curriculum redesign receive expert guidance and input form those members. Finally, the management team will oversee the dissemination of project findings and resources to the broader education and research communities**.**

Curriculum redesign team (Leftwich, Groth, Brush, Glazewski, Advisory Board, Teachers). The key members of this team will oversee the design, development, evaluation, and continuous improvement of the computer education licensure program for teachers. This includes the alignment of CSTA and ISTE standards to support computing education (technology integration, computer applications, and computer science).

Dual Enrollment team (Groth, Onesti, Richert, Beam, Leftwich, HS Teachers). The Dual Enrollment team will train the high school teachers to implement the lab portion of the I101 course into eight high schools in year one and an additional eight high schools in year two. This team will also help support teachers during their lab implementations and serve as expert resources to answer teacher questions. Teachers will work with the team to suggest improvements for the curriculum and for supporting the Dual Enrollment program.

Student recruitment team (Biggers, Beam, Leftwich, Glazewski, HS Teachers). The student recruitment team will work with teachers on strategies to recruit students to enroll in the Dual Enrollment course and other computer science courses offered at their school.

Community of practice team (Leftwich, Glazewski, Brush, Groth, Onesti, Richert, Teachers, Advisory Board). The communities of practice team will design and develop an online system to support teachers as they implement the I101 curriculum. The online system will enable teachers to upload and exchange curricular support materials for the class. In addition, the online system will facilitate discussion surrounding pedagogical approaches, high school teacher questions/clarifications related to Informatics concepts, and ideas for student recruitment into I101 and computing pathways. Since the curriculum for both Exploring Computer Science and CS Principles will be introduced to the high school teachers during the teacher education program, for additional communities of practice, we will also encourage teachers to participate in the online community of practice: CS10K Community (cs10kcommunity.org).

Research team (Leftwich, Glazewski, Brush, Advisory Board). The research team will oversee and support both the design and implementation of the project's research plan. This includes initial development of the research plan with major input from advisory board members, and planning and implementing the research plan itself. The team will work with high school teacher partners on Teacher Action Research projects. The research team will also be responsible for disseminating results of both preliminary and longer-term research findings.

Table 6 presents a timeline of major project activities.

Table 6. Project timeline and milestones.

	Strand 1			**Strand 2**			**Strand 3**		
Major Project Activities	**2013-2014**			**2014-2015**			**2015-2016**		
	Su	**Fa**	**Sp**	**Su**	**Fa**	**Sp**	**Su**	**Fa**	**Sp**
CEL Revisions									
Revising CEL program for CSTA standards	■	■							
Submit revised syllabi to Advisory Board			■						
Revise curriculum from Advisory Board suggestions			■						
Teachers enroll in CEL program (Cohorts 1 & 2)				■	■	■	■	■	■
Teachers implement action research projects.					■	■		■	■
Revise curriculum from teachers evaluation					■	■		■	■
Dual Enrollment Course (I101)									
Redesign I101 curriculum for HS	■	■	■						
Teachers receive training on I101, face-to-face				■			■		
Make curriculum changes based on teacher training				■			■		
Set up dual enrollment course in HS				■			■		
Implement I101 in HS					■	■		■	■
Make curriculum changes from Teacher feedback					■	■	■	■	■
Student Recruitment									
Provide teachers with recruitment plan for I101				■	■	■	■	■	■
Recruitment activities for computing pathways					■	■	■	■	■
Dissemination Activities									
Sharing CEL curriculum online (through website)				■	■	■	■	■	■
Disseminate project outcomes			■	■	■	■	■	■	■
Distribute curriculum							■	■	■
Project Management									
Face-to-face or virtual meeting with Advisory Board			■			■			■
Face-to-face/virtual meeting: Advisory Board, Teachers	■			■			■		
Consultation with teachers (I101 curriculum, CEL program, teacher action research plan)	■	■	■	■	■	■	■	■	■
Consultation with advisory board (I101 curriculum, CEL program, design/develop online community)	■	■	■	■	■	■	■	■	■