iSchools as Venues for Expanding the K-12 Computer Science Teacher Pipeline

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ABSTRACT

There is a national shortage of certified computer science (CS) teachers. While significant effort and resources have been put towards addressing this shortage, the number of newly certified CS teachers entering the profession each year remains low. In this position paper, we argue that Colleges of Information Studies (iSchools) can serve as fertile grounds for recruiting future K-12 CS teachers. The motivation for looking to iSchools as venues for expanding the K-12 CS teacher pipeline is threefold: (1) the content taught in undergraduate iSchool programs closely aligns with K-12 CS content, (2) undergraduate programs in iSchools are experiencing rapid growth in enrollment and have a diverse student body, and (3) iSchools focus on social aspects of computing and thus attract students well-suited for K-12 teaching as a profession. To develop these arguments, we review the content of top iSchool undergraduate programs, showing the alignment between iSchool undergraduate coursework and K-12 CS. Further, using the University of Maryland's Bachelor of Science in Information Sciences as a case study, we show how iSchools can serve as contexts for preparing future K-12 CS teachers. Collectively, this work seeks to expand how we think about recruiting future CS teachers, explicating arguing for iSchools as venues for expanding the K-12 CS teacher pipeline.

CCS CONCEPTS

• Social and professional topics → Model curricula; Computer science education.

KEYWORDS

K-12 Computer Science; Teacher Preparation; iSchools

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1 Introduction

There is growing interest and demand for computer science (CS) instruction to be a part of all students' K-12 learning experience. Calls to increase the presence of CS in K-12 can be heard across stakeholder groups, including parents, teachers, students, principals, and superintendents [9, 14]. While the interest is there, and district leaders are making CS a priority, there is a lack of certified CS teachers [2, 12]. This is despite a relatively large number of initiatives and professional development offerings designed to recruit and prepare K-12 CS teachers [11] and the rapid growth of enrollment in undergraduate CS programs [19]. This dearth of qualified teachers has long plagued efforts to expand K-12 CS education [10]. Several challenges face the field to increase the number of new K-12 CS teachers, including recruiting students interested in becoming K-12 CS teachers, having faculty and coursework in place to prepare new teachers, and having mechanisms to certify and place new K-12 CS teachers [5, 17].

Given the need to increase the number of certified K-12 CS teachers and the ongoing challenges of recruiting and preparing new teachers through existing recruitment pipelines, this position paper presents an alternative venue for recruiting future K-12 CS teachers: Colleges of Information Studies (iSchools). The motivation for looking to iSchools as venues for recruiting future K-12 CS teachers is three-fold: (1) the content taught as part of undergraduate degrees in iSchools has a significant amount of overlap with K-12 CS, (2) iSchool undergraduate programs are experiencing a period of rapid growth and attract a diverse set of students, and (3) iSchools' focus on the social aspects of computing and attract a student population well-suited for teaching. Additionally, whereas there are very clear career pathways for those graduating from traditional CS undergraduate programs (of which teaching is often not considered), students graduating with degrees from iSchools pursue a much wider array of careers, thus creating the situation where graduating students may be more open to considering alternative careers outside of industry.

In this position paper, we make the argument that iSchools can serve as generative venues for recruiting future K-12 CS teachers. To make this argument, we begin by demonstrating the overlap in content between K-12 CS and iSchool coursework by reviewing the content of undergraduate programs currently being offered at top iSchools. This mapping demonstrates the overlap between what students learn as part of an iSchool degree and its alignment with K-12 CS content. To more fully illustrate this overlap, we provide a case study of one particular iSchool undergraduate program, the University of Maryland's Bachelor's degree in Information Sciences. This case study also documents the rapid growth in enrollment and highlights the demographic and experiential diversity of students pursuing degrees in Information Sciences.

This paper concludes with a discussion of how this approach can fit into the larger conversation on strategies for recruiting new K-12 CS teachers. By creating new pipelines into K-12 CS teaching, especially pipelines that capture computationally savvy and socially-oriented students, we can begin to address the longstanding shortage of certified K-12 CS teachers.

2 iSchool Undergraduate Degree Coursework

Colleges of Information Studies, often referred to as iSchools, are primarily interested in the relationship between information, technology, and people, with an emphasis on the role of information in human endeavors [6]. iSchools are traditionally very interdisciplinary, comprised of faculty with varying backgrounds, including computer science, communications, education, library science, and the humanities [16, 18]. While iSchools have historically focused on graduate programs, the last decade has seen the rapid growth of undergraduate programs being offered by iSchools.

In this section, we demonstrate the overlap between K-12 CS and iSchool degrees with two analyses. First, we present an analysis of the coursework offered by top iSchools to showcase how the programs of study at iSchools align with K-12 CS content broadly. Second, we provide a more detailed picture of what students study to earn a bachelor's degree from an iSchool by presenting the core courses that comprise the University of Maryland's Bachelor of Science in Information Science program. By providing both a high-level overview of national iSchool programs and a detailed look at one program specifically, we showcase the significant overlap between iSchools coursework and K-12 CS content.

2.1 K-12 CS Content at Top iSchools

In this paper, we argue that iSchools are excellent venues for recruiting future K-12 CS teachers due to the overlap between what is learned as part of a bachelor's degree from an iSchool and what is taught in K-12 CS classrooms. To demonstrate this overlap, we analyzed the course offerings for undergraduate degrees offered by the top 10 iSchools in the United States of America[1]. For each program, we analyzed the undergraduate courses offered and mapped them onto the five major content areas of K-12 CS as defined by the Computer Science Teachers Association (CSTA) standards [3]: Algorithms and Programming; Computing Systems; Data and Analysis; Impacts of Computing; and Networks and the Internet. This list of CS concepts aligns with the K-12 CS framework and also directly maps on to the CS Praxis exam offered by ETS that is required for certification in many states.

For each top 10 iSchool program, we reviewed the publicly available materials for the undergraduate programs offered and mapped the content of the courses onto these 5 CS content areas. Table 1 presents the results of this analysis, listing relevant courses for each CS content area. For clarity, a given course was only mapped to the most relevant CS topic even though many courses will cover multiple CS topics. Additionally, only 400-level coursework and below were analyzed given the focus on undergraduate instruction (with a few exceptions for 500-level required courses). This means Table 1 is an intentionally conservative mapping as we expect every program has additional courses that could be included in this table. Note, many programs did not provide full syllabi, so mapping decisions were made based on the publicly available course descriptions.

As can be seen in Table 1, there is a high degree of overlap between the coursework offered in undergraduate iSchool programs and K-12 CS content. Eight of the 10 top iSchool programs have courses that cover all 5 of the major K-12 CS content areas. It is also noteworthy that all 10 programs offer courses on topics related to Impacts of Computing. This is important as this is a subject that is often overlooked in more technically demanding CS programs and also the topic that K-12 CS teachers report being the least prepared to teach and is often overlooked in K-12 CS classrooms [15]. It is also worth noting that a number of iSchool degree programs require students to take courses offered in computer science departments, further highlighting the connection between iSchools and CS departments.

Beyond the general requirements for a bachelor's degree from an iSchool, many programs offer specializations or concentrations that allow students to gain additional expertise in one area related to information sciences. Looking across the top 10 iSchool programs, there are several specializations that align with CS content and would provide future K-12 CS with additional expertise and knowledge that would be useful in the classrooms. The areas of specialization include data science (offered by 9 programs), cybersecurity and information assurance (offered by 5 programs), human-computer interaction (offered by 4 programs), user experience design (offered by 4 programs), and web design (offered by 3 programs). These CS-related specializations further highlight the alignment between iSchool programs and K-12 CS.

[1] Based on the U.S. News and World Reports 2021 "Best Library and Information Studies Programs" ranking: https://www.usnews.com/best-graduate-schools/top-library-information-science-programs/library-information-science-rankings

Table 1. Courses offered by undergraduate iSchool programs and how they align with K-12 CS content areas.

Institution	Undergraduate Degree(s)	K-12 Computer Science Content Areas				
		Algorithms & Programming	**Computing Systems**	**Data & Analysis**	**Impacts of Computing**	**Networks & the Internet**
University of Illinois Urbana-Champaign	BS in Information sciences	205*, 229	401, 446	203*, 206*, 324, 417	101*, 202*, 309, 311*	229, 324, 409, 429
University of North Carolina	BS in Information Science	Comp 110*, 512		201*, 202, 382*, 523*	384, 385*	201, 203
University of Washington	BS in Informatics	201*, 340*, 365	CSE142*, 314	180, 200*, 220, 330*	101, 200, 270, 350*	101, 314
University of Maryland	BS in Information Science	126, 326*, 377	346*	301, 311*, 327*	201*, 366	346*, 377
University of Texas	BA in Informatics BS in Informatics	304*		301*	303*, 310*	
Rutgers University	BS in Information Technology & Informatics	202*, 320	201*, 240	221, 330	200*	111, 320
Syracuse University	BS in Applied Data Analytics BS in Information Management & Technology BS in Innovation, Society, & Technology	256*, 263	195*, 233	300, 325, 359*, 387*	300, 301, 343*	195*, 233*, 263, 300
University of Michigan	BS in Information	106, 206*, 431	330, 370	106, 301, 334, 335, 410	106, 301, 429	339*, 431
Indiana University	BS in Informatics BS in Data Science	CSCI 200*, INFO 311	INFO 430, INFO 433	INFO101*, CSCI 310*,	INFO 202*, ILS 410*	INFO 360, INFO 368
University of Tennessee	BS in Information Sciences	360*	210*	201*, 380, 384	305	305

* Denotes a course that is required by the major

2.2 What is Taught in an iSchool Degree

Having shown the high-level overlap between bachelor's degree programs offered by top iSchools and K-12 CS content, we now present a more detailed look at one specific iSchool bachelor degree program to provide a more complete picture of what exactly constitutes a degree from an iSchool. To do this, we focus on the University of Maryland's Information Science (InfoSci) degree.

The InfoSci degree at the University of Maryland is a 4-year program of study that teaches students skills in technical areas such as database design, information architecture, web/mobile development, data analytics, and cybersecurity alongside topics from the social sciences and the humanities. The stated goal of this program is to address the growing and unique need for information professionals who understand complex social and organizational issues. The program includes 10 core InfoSci courses and 5 major InfoSci electives. Along with the required iSchool coursework, all students must take 2 courses from a range of disciplines, including Natural Sciences, History and Social Studies, Humanities, and Writing.

The goal of this section is to provide a detailed picture of the coursework students take en route to earning a bachelor's degree from an iSchool. This section highlights the alignment between K-12 CS content and the coursework required for students pursuing undergraduate degrees in iSchools. Looking across the 10 core courses presented in this section, there is 100% coverage of the five core CS content areas defined by the Computer Science Teachers Association (CSTA) standards [3] (shown in row 4 of Table 2). Due to this alignment, the University of Maryland's InfoSci degree provides an excellent foundation for becoming a CS teacher. To further demonstrate this, Table 2 shows the alignment between the University of Maryland's InfoSci program and the CS Knowledge and Skills needed to teach K-12 CS as defined by the CSTA standards for CS Teachers [4]. Importantly, every course listed in Table 2 is a required course for InfoSci students. This means every student who graduates with an InfoSci degree has taken coursework that covers all content areas and indicators associated with becoming a K-12 CS teacher.

2.2.1 InfoSci Core Coursework

In this section, we briefly present the 10 InfoSci required core courses to illustrate what the University of Maryland has defined as essential knowledge for InfoSci students. This list does not include required pre-requisites, including INFO 126: Introduction to Programming for Information Sciences.

INFO 201: Introduction to Information Science: Heroes and Villains in the Age of Information. This course examines the effects of new information technologies on how we conduct business, interact with friends, and go through our daily lives. Throughout the course, students work to understand how technical and social factors have influenced the evolution of information society and evaluate the transformative power of information in education, policy, and entertainment, and the dark side of these changes.

Table 2. Mapping the University of Maryland's InfoSci courses to the CS knowledge and skills standards for teachers as defined by the CSTA.

Indicator	Relevant Concepts	Applicable InfoSci Course(s)
1a. Applying CS Practices	Fostering an Inclusive Computing Culture	335
	Collaborating Around Computing	126, 326, 327, 335, 346, 362
	Communicating About Computing	126, 326, 327, 352, 362
	Recognizing and Defining Computational Problems	126, 311, 326, 327, 346, 362
	Developing and Using Abstractions	126, 326, 327, 346
	Creating Computational Artifacts	126, 326, 327, 346, 362
	Testing and Refining Computational Artifacts	126, 326, 327, 346, 362
1b. Apply knowledge of computing systems	Apply knowledge of how hardware and software function to input, process, store, and output information	126, 311, 326, 327, 346
1c. Model networks and the Internet	Model how computing devices connect via networks	346
1d. Use and analyze data	Collect, store, transform, and analyze digital data to better understand the world and make more accurate predictions.	311, 346, 352, 362
1e. Develop programs and interpret algorithms	Design, implement, debug, and review programs in an iterative process using appropriate CS tools and technologies.	126, 326, 327, 346
	Interpret algorithms and explain tradeoffs associated with different algorithms.	311, 326, 346
1f. Analyze impacts of computing	Analyze how people influence computing through their behaviors, cultural norms, and social interactions	311, 352, 362

INFO 311: Information Organization. This course examines the theories, concepts, and principles of information, information representation and organization, record structures, description, and classification. Topics to be covered include the methods and strategies to develop systems for storage, organization, and retrieval of information in a variety of organizational and institutional settings, as well as policy, ethical, and social implications of these systems.

INFO 314: Statistics for Information Science. This course explores basic concepts in statistics including measure construction, data exploration, hypothesis development, hypothesis testing, pattern identification, and statistical analysis. The course also provides an overview of commonly used data manipulation and analytic tools. Students will practice working with these techniques and tools to create information resources that can be used in individual and organizational decision-making and problem-solving.

INFO 326: Object-Oriented Programming for Information Science. This course is an introduction to programming, emphasizing understanding and implementation of applications using object-oriented techniques. Topics to be covered include program design and testing as well as the implementation of programs.

INFO 327: Database Design and Modeling. This course is an introduction to databases, the relational model, entity-relationship diagrams, user-oriented database design and normalization, and Structured Query Language (SQL). In this course, students develop both theoretical and practical knowledge of relational database systems.

INFO 335: Teams and Organizations. This course explores team development and principles, methods, and types of leadership with an emphasis on goal setting, motivation, problem-solving, and conflict resolution. It also investigates the principles of managing team projects in organizations through planning and execution including estimating costs, managing risks, scheduling, staff and resource allocation, communication, tracking, and control.

INFO 346: Technologies, Infrastructures, and Architecture. This course examines the basic concepts of local and wide-area computer networking including an overview of services provided by networks, network topologies and hardware, packet switching, client/server architectures, network protocols, and network servers and applications. The principles and techniques of information organization and architecture for the web environment will be covered along with such topics as management, security, authentication, and policy issues associated with distributed systems.

INFO 352: Information User Needs and Assessment. This course focuses on the use of information by individuals, including the theories, concepts, and principles of information, information behavior, and mental models. Methods for determining information behavior and user needs, including accessibility issues, will be examined and strategies for using information technology to support individual users and their specific needs will be explored.

INFO 362: User-Centered Design. This course provides an introduction to human-computer interaction (HCI), with a focus on how HCI connects psychology, information systems, computer science, and human factors. User-centered design and user interface implementation methods discussed include identifying user needs, understanding user behaviors, envisioning interfaces, and utilizing prototyping tools, with an emphasis on incorporating people in the design process from initial field observations to summative usability testing.

INFO 490: Integrative Capstone. The capstone course provides a platform for InfoSci students to apply a subset of the concepts, methods, and tools they learn as part of the program to address an information problem or fulfilling an information need.

2.2.2 InfoSci Cognate Areas

Along with completing the core set of courses, students in the InfoSci program at the University of Maryland can specialize in one of four different InfoSci cognate areas. In this section, we present each cognate area to provide insight into the types of expertise developed in an iSchool undergraduate degree.

Cybersecurity & Privacy Specialization. In pursuing a specialization in cybersecurity and privacy, students learn human-centered cybersecurity skills and perspectives, and prepare to launch careers in the cybersecurity field with particular emphasis on management, policy, and governance-related functions. Courses in this cognate area include Human-Centered Cybersecurity; Ethical Hacking; Privacy, Security, and Ethics for Big Data; and Decision-Making for Cybersecurity.

Data Science Specialization. In pursuing a specialization in data science, students develop an understanding and skills for managing, manipulating, and mobilizing data to develop insight, create value, and achieve organizational goals in a wide range of sectors. Courses in this cognate area include Decision-making for Information Science; Dynamic Web Applications; Advanced Data Science; Data Sources and Manipulation; and Introduction to Data Visualization.

Digital Curation Specialization. In pursuing a specialization in digital curation, students can launch careers in which they collect, digitize, appraise, curate, and disseminate information assets effectively and efficiently. Courses in this cognate area include Introduction to Digital Curation; Information Ethics and Policy; Digital Curation Across Disciplines; Tool and Methods for Digital Curation; and Digital Curation Research in Cultural Big Data Collections.

Health Information Specialization. In pursuing a specialization in health information, students learn about the ways data informs the decisions made by health professionals, patients, and policymakers with an emphasis on equity and accessibility. Courses in this cognate area include Design and Human Disability and Aging; Designing Patient-Centered Technologies; Consumer Health Information; and Health Data Analysis.

3 iSchool Undergraduate Enrollment

A second key dimension to why iSchools can serve as excellent recruiting grounds for future K-12 CS teachers stems from the students the programs attract and the rate at which iSchool undergraduate programs are growing. Having a diverse student population to recruit future teachers from is essential as research shows the importance of having teachers that reflect the racial and gender background of the students they are teaching [7, 8]. Thus, if we are going to address longstanding racial and gender disparities in the field of computing, we need to prepare a racially and gender-diverse teaching population. Again, using the University of Maryland as a case study, we now present data showing why iSchools can be generative venues for recruiting future CS teachers to achieve this outcome. Table 3 presents demographic data of students currently enrolled in the University of Maryland's InfoSci Degree program alongside students currently enrolled in the University of Maryland's computer science (CS) program, and the full undergraduate student body.

Table 3. Enrollment information for the 2020-21 academic year.

	InfoSci	**CS**	**All**
Enrollment	1,160	2,603	30,875
Race/Ethnicity	% (count)	% (count)	% (count)
Asian	29.4% (341)	37.1% (965)	19.1% (5,890)
Black/African American	22.0% (255)	7.3% (191)	12.0% (3,700)
Hispanic	8.4% (98)	5.1% (132)	9.9% (3,045)
Two or more	4.6% (53)	3.7% (96)	4.7% (1,438)
White	27.6% (320)	32.4% (844)	46.6% (14,387)
Other*	8.0% (93)	14.4% (375)	7.8% (2,415)
Gender			
Male	71.5% (829)	79.1% (2,060)	52.0% (16,047)
Female	28.5% (331)	20.9% (543)	48.0% (14,828)
First Gen.			
First Gen.	29.3% (340)	14.4% (375)	19.4% (5,981)
Not First Gen.	70.7% (820)	85.6% (2,228)	80.6% (24,894)

* American Indian, Foreign, Native Hawaiian, and Unknown

Compared to CS (which is the student population historically targeted for recruiting future CS teachers), the iSchool program has a higher percentage of Black/African American and Hispanic students. In fact, there are more Black/African American students in the InfoSci program than the CS program, despite having half as many students overall. Additionally, the iSchool has a higher percentage of female students and first-generation students relative to the CS program. It is important to note, University of Maryland's program is not unique in these gender and racial differences. The 2020 Taulbee report shows iSchools graduate a higher percentage of female, Black/African American, Hispanic, and multiracial students compared to CS and Computer Engineering programs [19]. Collectively, this demonstrates how iSchools can help diversify the CS teacher profession, and thus, betters serve students from historically excluded populations.

Part of the explanation for the diversity of the iSchool undergraduate student body relative to CS, both at the University of Maryland and beyond, is how the mission, scholarship, and coursework found within iSchools speak to issues of equity, diversity, and inclusion and provide opportunities for students to engage in such topics. For example, the University of Maryland's iSchool offers courses on the design of inclusive technologies, information and technology needs of different populations, ethics in technology and big data, and human rights and social justice roles of cultural heritage institutions.

Along with a diverse student population, iSchool undergraduate enrollment is growing. Figure 1 shows the growth in enrollment of the InfoSci program since its founding in the

2016-17 school year. In the five years since its founding, the InfoSci program has grown tenfold and is now the fourth most popular major at the University of Maryland. This growth in enrollment, coupled with the racial and gender diversity of the students the program attracts, further highlights why iSchools can serve as generative venues for recruiting future K-12 CS teachers.

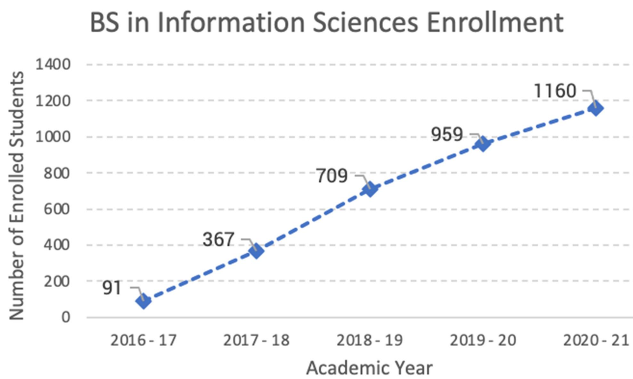

Figure 1. Undergraduate enrollment by year in the InfoSci program

4 Discussion and Conclusion

As the presence of CS in K-12 schools continues to grow, so too will the need for qualified K-12 CS teachers. Yet, despite the rapid growth in undergraduate CS programs, the number of CS teachers has not kept pace with the demands of schools and districts. In this position paper, we argue that one potentially generative approach for recruiting future K-12 CS teachers is to look beyond CS departments and start recruiting students enrolled in iSchools.

As we have shown in this paper, the coursework students take to earn a bachelor's degree from an iSchool has significant overlap with the content that is taught in K-12 CS classrooms. This includes technical knowledge, such as expertise in programming and algorithms, as well as knowledge on how computing is used and the impact it has on society. Along with significant content overlap, iSchools are succeeding in attracting a racially and gender diverse student population. Thus, recruiting future K-12 CS teachers from iSchools can also help develop a more diverse teaching force, which is an important factor in addressing long-standing issues with equity and underrepresentation in computing fields.

While building pathways in iSchools may be beneficial to increasing and diversifying the K-12 CS teacher workforce, there remain significant challenges this approach does not address. Central among them is having certification programs in place and the faculty in colleges of education to prepare future K-12 CS teachers. Knowing the content is only part of the knowledge teachers need to be successful. Additionally, there are significant gaps in K-12 CS certification programs and faculty expertise in teacher preparation programs [5, 17].

A second challenge stems from making iSchool students aware of teaching as a potential profession and having faculty and staff in place in iSchools to introduce students to the idea of K-12 CS as a career choice and answer questions and support them should they choose to pursue that path. To date, a majority of advocates and researchers in CS education reside in CS departments, thus having access to students in iSchools can be a challenge. However, given how interdisciplinary iSchools are and the number of computing-related faculty in iSchools, bridges often already exist between the departments or colleges.

A third challenge related to the goal of preparing future K-12 CS teachers in an iSchool stems from the different ways computing disciplines think about, use, and thus teach shared computing concepts and practices. The 2020 ACM/IEEE Computing Curricula report [1] makes distinctions between computing programs such as computer science, computing engineering, information systems, and information technology. In doing so, it highlights the fact that concepts that are shared across computing fields play unique roles and have distinct characteristics based on sub-discipline. As such, the way the material is taught may also differ by sub-discipline. In moving CS teacher preparation into iSchools, this same form of disciplinary thinking may occur, resulting in CS teachers who bring an iSchool-informed lens to the nature of CS content. While we think an iSchool perspective that foregrounds the implications of computing on people and society may be broadly useful if the goal is to prepare all students for the broadest set of computing endpoints [13], it may have implications for those students who are set to purse CS in higher education. However, given the students coming through an iSchool pathway will still take coursework on CS pedagogy and will often end up teaching existing CS curricula steeped in conventional CS conceptualizations, this question of disciplinary variations with the computing landscape seems minor relative to the larger issues of a lack of qualified teachers this effort seeks to address.

The need for high-quality K-12 CS teachers is already high and will only continue to grow as the presence of CS continues to expand in K-12 schools. In response to this, we need new strategies for expanding the K-12 CS teacher pipeline. In this paper, we argue that iSchools can serve as productive venues for recruiting future teachers given the overlap in content between iSchool coursework and K-12 CS content. Further, the rapid growth in enrollment in iSchools and the diversity of their student bodies also point towards iSchools as venues for recruiting future K-12 CS teachers. The next challenge becomes working with and in iSchools to help raise awareness of CS teaching as a potential career, work already underway at the University of Maryland and hopefully other universities soon.

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