The Use of Online Materials in Undergraduate Computer Science Classrooms:
Examining Factors for Adopting New Curriculum and Instruction

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***Abstract*— We examined how 63 instructors used the EngageCSEdu digital collection and their ratings of its ease of use and usefulness. The collection contains over 1400 digital resources for teaching CS1 and CS2 classes. Forty-four percent of instructors accessed materials and used them in their classrooms. Most common use was for in-class exercises; 25% used materials for homework assignments. Respondents used materials one time (48%) or a few times (58%); instructors did not use materials to redesign whole courses. Sixty-four percent adapted materials they found on the site by changing difficulty level, changing content such as programming languages or adding/deleting parts of the lesson. Many instructors used materials as background sources to create their own materials.**

Keywords—Digital Collections; Computer Science education

I. INTRODUCTION

Google and the National Center for Women and IT (NCWIT) recently established EngageCSEdu as a digital library collection for learning materials for computer science instructors for first and second year undergraduate courses [1]. (The website can be found at: www.engage-csedu.org). The project has curated over 1400 instructor-contributed curricular materials. Our research examines how first and second year computer science instructors perceive the site and implement its materials. The impetus for the project is the recognition of the importance of introductory courses in retaining women in computing majors. Materials are selected for inclusion based on their use of at least one "Engagement Practice" (EP). EPs are teaching and learning strategies that research suggests may help retain women in computing.

Digital collections organize, archive, and deliver a mixture of traditional and innovative curriculum and materials to teachers [2]. Collections provide materials for higher education faculty [3] or to K-12 science teachers who use collections such as the National Science Education Digital Library (NSDL) and the Digital Library for Earth System Education (DLESE) [4][5]. Learning resources include lesson plans, student exercises, assessments, links to interactive exercises, educational data bases and other educational tools [6]. Teachers can access reviewed or curated collections screened for quality and organized by taxonomies relevant to their users.

The quarter-century old Technology Acceptance Model (TAM) model [7] is a framework to explain adoption for a wide variety of new technologies as diverse as computerized hospital record systems and self-driving cars [8]. The TAM model [9], broadly stated, predicts technology adoption from the perceived ease of use of the technology and its perceived usefulness; these perceptions are mediated by external variables, often conceived of as system characteristics, or the attributes of whatever technology is being adapted. For example, Aldunate and Nussbaum [10] found that early adopters of digital whiteboards were much more likely to perceive the adoption process as involving "no effort," while believing the technology provided substantial benefits for instruction; the opposite was true for later adopters. A wide range of other variables also enter into adoption patterns, such as norms encouraging use at a workplace [11], time and access issues [2], institutional factors not related to the technology [12][13], and the quality and characteristics of professional development about technology use [14].

Past studies have looked at adoption and adaptation of digital collections for science education. Sumner [6] found most adoption decisions to be driven by perceptions of the usefulness (versus ease of use) of the online resources for teachers, as well as how the collection helped teachers make informed judgments about the quality of resources. Matsuick [15] reported that many potential users did not believe that accessing a digital collection was significantly better than using a search engine. McMartin [2] also found that

instructors were more likely to use Google to find educational materials, but used collections to learn about specific instructional methods, primary source material, and professional development materials. The same study did not find any significant problems with ease of use for most instructors navigating digital collections. Both the McMartin and Matsuick studies, as well as Harley [16] and Lui [17] found that a lack of awareness among potential users about the existence of collections to be the greatest barrier to their gaining wider use.

Researchers also examined how instructors use and adapt the materials accessed from collections. Manduca [18] provided descriptions of the types of resources used in classrooms. The same author [19] provided insight into how user behaviors can be leveraged to encourage wider use of the collections. In a large-scale study by McMartin [2], the authors outlined the most frequent types of digital resources used by instructors (simulations and datasets); most materials were used for lectures. Many also used materials for professional development and as preparation for teaching.

Digital collections can also support the use of alternative, innovative or more student-centered instructional methods. Manduca [18] found that instructors view instruction in the context of course content. Teachers turn to colleagues and mentors first when formulating their teaching methods, then look for resources that support these practices. Harley [16] found that some teachers even avoided using collections because they did not support their existing methods of instruction. In contrast, Green [20] found that instructors reported that the use of digital images from collections changed instruction for 75% of instructors, although this finding was limited to materials used for lecture.

The current study examines three research questions.

1) What are the perceived usefulness and ease of use considerations for the EngageCSEdu users?
2) How do instructors use the materials they access from the site? How do instructors adapt materials?
3) How do instructors use materials to support instruction?

II. Method

The pilot study uses structured interviews and an online survey to ask instructors about their use of the site and its materials.

We interviewed fifteen instructors using a structured interview protocol during January – April 2016. We asked instructors where they first heard about the site, how they used the site, and if they accessed materials for use in their classrooms. We also asked how instructors adapted material and asked for ratings of the usefulness and value of the site. Interviews allowed for additional probing questions to provide more detailed descriptions. Forty-eight additional instructors answered the online survey with the same questions as the interviews.

Potential participants were 197 instructors who have established accounts with EngageCSEdu. The final list of potential respondents excluded instructors who had obvious ties to Google or NCWIT, and members identifying themselves as students. We considered the resulting respondents as a convenience sample who answered email solicitations to answer the survey, or who agreed to an interview from email or telephone contacts. The sample accounted for 32% of the registered users, but we did not reach other visitors who were not registered on the site.

Respondents were 61% female, and 39% male; 74% white, 3% African-American, 9% Asian-American; the remaining respondents did not wish to identify their race/ethnicity. On average, instructors reported teaching computer science for 17 years. Academic positions were represented by full professors (41%), associate professors (29%), adjunct/teaching track instructors (16%), and assistant professors (2%).

We analyzed interview and textual responses by coding for dominant themes and connections between themes using content domain analysis [21].

III. Results

A. Usability and Usefulness

We asked a series of questions about how instructors used the site (other than linking to or downloading materials), and if, and how they found the site useful.

We first asked where respondents heard about the EngageCSEdu website. The greatest number (34%) heard about the site at a conference or other presentation, while 23% first found out about the site from an email or other mailing. From those instructors interviewed who heard about the site at a conference, all six said they had seen materials at an informational booth at SIGCSE, the Special Interest Group on Computer Science Education.

We asked instructors what they did when they visited the site (respondents could answer all that apply). Thirty-five percent (35%) reported browsing through materials, 23% looked for specific materials, and 21% read about engagement practices, an informational section on instructional practices and content meant to encourage student engagement. Sixteen percent (16%) said they read descriptions of materials without linking or downloading materials. Fourteen percent (14%) said they contributed materials to the site.

We asked instructors to rate the usefulness of the site, if they would recommend the site to a colleague, and if they would return to the site in the future. On a one to four scale of usefulness (not at all (1) to very (4)), instructors gave an average rating of 2.8 (“useful”); all but two instructors said they would recommend the site to a colleague, and all but one said they would return to the site in the future.

Responses varied to the question “how would you improve the site”. Two instructors suggested changing the organization of the site and its taxonomy. Many suggested cosmetic changes to the site’s design such as the addition of icons and better labeling. Some respondents wanted to add major functional features such as the ability to collaborate with others. Eight instructors called for additional search function criteria (e.g., author’s names) or more specific search terms for types of

assignments. Overall, comments did not indicate any major problems with the ease of use of the site. We did not see recommendations for major overhauls of site navigation or expressions of serious frustration with the site's design or functioning that caused users to quit the site before gaining access to materials.

B. Use and adaptation

We wanted to know how instructors used materials with their students. We asked about the types of materials accessed, how many times during a term the materials were used, and if, and how the materials were adapted.

Forty-four percent of those who answered the survey reported downloading or linking to materials from EngageCSEdu. Respondents were asked to choose one material they used with their students and describe what they did in their classrooms with the material.

Instructors used materials for in-class exercises (25%), out-of-class labs or homework (50%), supplementary exercises for individual students (13%), and as background material for lectures (12%). When asked how often they used materials, 42% percent said they used materials once during the semester, while 58% used material several times throughout the semester. No one used materials throughout the entire semester.

Table 1 Primary uses for EngageCSEdu website

Activity	**%**	**Examples from collection**
In-class exercises	25%	*This POGIL activity is intended as an in-class activity for a CS 1 course (Java), potentially replacing a lecture, lab, or recitation section. The activity introduces students to the Java operators % and /, and the difference between integer and floating-point division.*
Out-of-class labs	50%	*Crazy 8's: Students are asked to complete the implementation of a Java GUI application for the card game Crazy Eights.*
Supplementary exercises for individual students	13%	*In this pair programming assignment, students work with several DNA-based problems as an introduction to bioinformatics, to familiarize students to strings.*
Background materials	12%	(Review of multiple materials)

We also asked these instructors to rate the materials for their usefulness and value. Questions asked about student learning with new material, the fit of material to existing curricula, and the ease of use of new materials. Ratings for these questions were uniformly high, with average ratings between three and four on a four point agree/disagree scale.

Table 2 EngageCSEdu: Usefulness and value (agree or disagree).

Agree or Disagree	Mean
The new materials or lessons helped my students learn novel content not covered before in my course	3.22
The new material helped my students learn more efficiently the content I have covered in past courses	3.22
The new material engaged my students	3.57
I will use the new material in classes in the future	3.52
The new material fit into my existing lessons or curriculum	3.72
I had to modify the new material to fit expectations for my teaching from my department or institution	3.37
The new material was easy to use in my classroom	3.42

Note: Based on four point scale, strongly disagree to strongly agree.

C. Adapting materials

Of those using EngageCSEdu materials, 64% reported adapting or substantially changing materials for their own use. Types of adaptations fell into one of several categories, including 1) adjustment of materials for the difficulty level of students, 2) alterations to basic lesson content (e.g., changing the programming language), 3) adding or deleting content to fit existing class plans or curricula, and 4) using multiple lessons from the site as source material for creating entirely new lessons.

Instructors adapted material to adjust for the skill level of their students. Usually this meant adapting material from more selective institutions for use at less selective institutions such as community colleges. One instructor described an out-of-class exercise for creating an interactive card game and her adaptation of the material. In this case the material was adapted to adjust the difficulty level of the lessons for her students by breaking up lessons in more manageable chunks, adding explanations, and going over material in class:

Instructors made other changes to lesson content, with alterations to programming languages. For instance, three participants changed programming languages used in the original lessons. Other instructors adapted material by adding or removing content to be more compatible with existing lesson plans.

Adaptation also involved instructors using multiple materials as a base, or source for creating entirely new lessons. Instructors described reviewing materials to get ideas, then creating their own lesson based on what they gained. Others reported taking materials from several sources and blending them into one lesson.

Some assignments and exams I used as an inspiration that helped me move the course in a particular direction, having

seen that other experienced instructors emphasize those directions. [Participant 21]

I looked at a lot of different materials because I wanted to prepare a better brief lecture that explains the process in an easier and relevant manner [Participant 16]

Instruction

The site is partly built around the use of "Engagement Practices", a mixture of instructional practices (e.g., pair programming or inquiry-based learning) and content characteristics such as materials that avoid or mitigate stereotype threats, or address misconceptions about computer science. Engagement practices are accessed on the site through a link to descriptions of each practice and tabs for examples, NCWIT resources and additional resources. When materials in the collection are accessed, the engagement practices embodied in the material are listed on the cover sheet and the materials page links to information about the practices in the lesson.

Twenty-two percent of instructors read about engagement practices when they visited the site. During interviews, we asked instructors if they visited the site with the intention of finding new instructional methods or ideas for changing instructional methods. None of these respondents said they came to the site with these intentions, but said they were looking for resources that supported existing practices already used in their classrooms. All of the instructors interviewed reported visiting the engagement practices links embedded in the materials and reading about the practices.

Two instructors providing descriptions of adaptations said they changed instructional techniques found in materials. One change involved changing a group project to a pair programming exercise, the other extended an exercise meant for one class period to a multiple class project.

IV. Discussion

A. What are the perceived usefulness and ease of use considerations for the EngageCS.edu users?

Ease of use did not appear to be a major consideration in inhibiting the use of the site, especially since recent design upgrades made the site faster and improved usability. Users tended to give high ratings to the site's usability, and no one reported any serious problems with the site's navigation or functionality. For those visiting the site, 44% linked to materials and used them in their classrooms, suggesting that the site provides useful materials to computer science instructors. The same instructors gave uniformly high ratings for the value and usefulness of the materials they accessed. We believe the major barrier to wider use is dissemination; most instructors heard about the site at conferences, mailings or through peers. Wider use may depend on reaching instructors outside of these specialized contexts.

B. How do instructors use the materials they access from the site? How do instructors adapt materials?

Instructors' employed materials for in-class exercises and homework assignments for their students. Use occurred during one class, or during a few classes throughout the term, but instructors in this study did not use the site for dramatic course redesign efforts or to change substantial parts of a course. This is in keeping with the types of materials in the collection and with the original intent of the site's designers. Efforts to expand the site to include whole courses or course modules may not help educators who seem primarily interested in materials for smaller-scale additions to their classes.

Most instructors adapted the materials they found on the site. Instructors made changes in response to the need to fit materials into existing lesson plans or to accommodate students' skill levels. In most cases, adaptation retained the original structure of the lessons, but changed the amount of class time needed for the lesson. Instructors also provided extra scaffolding and support to make the lesson less difficult for students through the addition of explanatory text, breaking up lessons into more manageable parts, or eliminating parts of lessons perceived as more difficult. Fewer adaptations involved changing the instructional methods used with students. One design recommendation arising from these findings would be the added provision of suggestions on how to adapt lessons as part of the informational sheet for each material.

C. How do instructors use materials to support instruction?

Instructors reported visiting the engagement practices section of the site to learn about alternate teaching practices. However, few reported searching for materials based on specific engagement practices, instead, most searched for materials that supported or extended existing teaching practices. This finding supports past research by Maduca [19] and Harley [16] who found that teachers tend not to use collections to look for new ways of teaching, but somewhat conflicts with Green's [20] who said instructors changed their instruction when incorporating new materials. McMartin's [2] finding that teachers tend to favor collections over search engines when searching for information about pedagogy suggests that the engagement practices component of the site is potentially a valuable part of the EngageCSEdu collection, but that finding materials with specific instructional practices is not the primary motivation of most users.

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