From Workshops to Classrooms: Faculty Experiences with Implementing Inclusive Design Principles

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ABSTRACT

Computer science (CS) and information technology (IT) curricula are grounded in theoretical and technical skills. Topics like equity and inclusive design are rarely found in mainstream student studies. This results in graduates with outdated practices and limitations in software development. A research project was conducted to educate the faculty to integrate inclusive software design into the CS undergraduate curriculum. The objective is to produce graduates with the ability to develop inclusive software.

This experience report presents the results of teaching inclusive design throughout the four-year CS and IT curriculum, focusing on the impact on faculty. This easy-to-adopt, high-impact approach improved student retention and classroom climate, broadening participation. Research questions address faculty understanding of inclusive software design, the approach's feasibility, improvement in students' ability to design equitable software, and assessment of the inclusiveness culture for students in computing programs.

Faculty attended a summer workshop to learn about inclusive design and update their teaching materials to include the GenderMag method. Beginning in CS0 and CS1 and continuing through Senior Capstone, faculty used updated course assignments to include inclusive design in 10 courses for 44 sections taught. Faculty outcomes are positive, with the planning to include inclusive design and working with other department faculty most engaging. Faculty were impressed by student ownership and adoption of inclusive design methods, particularly in the culminating capstone senior project.

CCS CONCEPTS

• Human-centered computing • Applied computing • Education

KEYWORDS

Inclusive design, computer science education, pedagogy

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1 INTRODUCTION

Computer science (CS) and information technology (IT) curricula are widely taught in conformance to ACM [1] and ABET [2] standards, with a focus on theoretical and technical skills. Examinations, programs, and other educational artifacts often assess knowledge mastery. Often, the significance of a student programmer's work is emphasized at the functional level, meaning that students stick to an assignment's rubric, seeking to meet an assessment, without fully understanding the broader impact and real-world applications of their skills. This approach frequently fails to consider the widespread impact their work will have on their users, particularly inclusive design.

Inclusive software design methods, which consider different approaches that users have to work with software, have been identified as part of the GenderMag method [3]. GenderMag, short for gender inclusiveness magnifier, formalizes users' approaches to problem-solving as they explore new software. It also supports inclusive design, identifying features allowing all users to use the software, not just selected populations. GenderMag was developed

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to assist software developers in implementing inclusivity methods into the software. This work explores the use of GenderMag by CS/IT faculty in their classes and addresses the broader impact of their students' work. Using GenderMag as a template to create a curriculum for teaching inclusive design, the faculty and researchers aim to expand the understanding of computer science beyond technical skills and emphasize the importance of considering diverse perspectives and user experiences. IRB consent was obtained for this work.

2 PRIOR WORK

2.1 Importance of Inclusive Design

Prior work describes how technology is often created with an imaginary "average user" in mind and that this hypothetical user is usually of a social or a culturally dominant race, gender, age, and class, who is affluent, and comfortable with technology with no disability [4, 5]. This practice is only feasible for users who fit within these categories. With a growing diverse community, inclusivity and accessibility must be discussed during design implementation. To avoid this software bias, it is important for individuals who are a part of the software development life cycle to have prior knowledge and skills to avoid making assumptions about users. Undergraduate students should be exposed to inclusive design, as students lack the knowledge, experience, and perceptive thinking skills to understand how their design choices can exclude different groups of users. This exposure will then be integrated into their professional responsibilities.

2.2 The GenderMag Method

Building upon foundational research, GenderMag is an inclusive design implementation approach with tools developed to identify and address inclusiveness issues in software user interfaces [3]. It enables software practitioners to find gender-inclusivity "bugs."

This evidence-based technique includes a set of personas used in human-computer interaction (HCI) research to give insight into users by making details more personable. The personas (Abi, Pat, Tim) are outlined with five facets that make up their cognitive style. The facets include 1) motivation for using technology; 2) information processing style; 3) computer self-efficacy; 4) learning style (by process or by tinkering); and 5) attitude toward risk. These personas are created to model different types of users. The persona identities are created to support a range of cognitive styles (facets) from low technology knowledge and competency to highly expert technology skills [6].

The GenderMag approach employs cognitive walkthroughs for personas and their facets. Within the GenderMag walkthrough process, each phase of a use-case or scenario is examined, with queries regarding the individual subgoals and actions required for user success. The GenderMag approach does not focus exclusively on gender but is focused on inclusive design for all.

The GenderMag website provides resources that allow faculty to teach students about the significance of inclusivity, diversity, and user-centered design in software development [6-10]. For example, it helps students consider who their end users are when developing GUIs for their applications and how their users will be able to interact with them. Earlier work implementing GenderMag in the undergraduate classroom improved student retention, course outcomes, a sense of inclusion, and teamwork [11]. Incorporating methods like these is essential to promote inclusivity, enhance user experience, and mitigate biases.

2.3 Teaching Inclusive Design

Inclusive curriculums are desired by academics, and inclusive classrooms, accompanied by pedagogical training, have encouraged faculty to move away from a fixed mindset, modifying teaching approaches to promote inclusivity. [12-14]. Earlier work on teaching inclusive thinking has focused on undergraduate computing students [15, 16]. Teaching interventions were focused on HCI courses, with accessibility lectures, and not available throughout the curriculum for all students.

Earlier work on teaching inclusive design identified the pedagogical content knowledge (PCK) needed to teach GenderMag [17]. More recently, the CIDER Assumption Technique has been used to help students in an interaction design class develop inclusive approaches to design work [18]. Importantly, reasons why CS faculty adopt new teaching practices identified the importance of 'fit' with existing practices and tools and the logistics required to implement an innovation. Factors decreasing faculty interest in implementing innovations include lack of time, logistics, and contentment with current practices [19]. Leading technology companies, like Apple, Microsoft, and Google, implement inclusivity within their designs [20]. Students should be exposed to inclusive design throughout their undergraduate curriculum, not just in HCI courses, so they graduate with the necessary skills already developed to create inclusive technology.

3 APPROACH

The CS faculty at a public urban Hispanic serving institution (HSI) university identified ten CS/IT courses, distributed over all four years of undergraduate study. From the introduction in CS0/CS1 through Senior Capstone, courses in each year were selected to introduce and reinforce inclusive design methods, ensuring that students in the CS and IT majors would have at least 5 required courses in their major program using inclusive design. Transfer students have at least 3 required courses. Participating faculty represent a standard undergraduate program, many without inclusive design expertise. The faculty attended a summer workshop to prepare for this research.

The impact of this approach, measured over all four years of the undergraduate curriculum, determines if students exposed to inclusive design as part of their core CS/IT education program will design more inclusive software when compared to students not exposed to inclusive design. The effort intends to maintain the existing undergraduate courses and integrate equity and inclusion into the work that students are already doing. The research presented here provides the faculty perspective on adding inclusive design to lectures and discusses how this method can broaden participation in computing.

3.1 Inclusive Design

One of the objectives of implementing these inclusive teaching methods into a four-year university curriculum was to uncover gender-inclusivity issues in software and user interfaces. This two-year-long trial was also meant to reveal how it would specifically affect faculty who volunteered to implement these new methods into their already packed semester.

The importance of inclusive software is known, but it is not clear how to infuse inclusive software design methods into the undergraduate CS and IT programs without displacing core curriculum. This is particularly challenging as the expertise of many department faculty lies outside the area of inclusive software development. Working with the existing standard ABET CS and IT curriculums, a minimum set of courses was identified, providing a pathway for all majors to learn inclusive design across all 4 years. The course sequence comprises required courses in core areas, taken by all students, with an introduction to inclusive design in the first year, reinforcement in the second and third years, and a demonstration of mastery in the fourth year.

Over the course of the project, 14 faculty participated in the educate-the-faculty workshop, presented by two moderators, with 4 faculty later retiring or leaving the university, resulting in 10 faculty using GenderMag in their classrooms. Using backward design [21], the faculty could develop assessments and modify 10 assignments to include one inclusive design assignment in each selected class, with multiple sections taught annually. Faculty collaborate on developing shared curriculum materials for courses taught by different faculty during the academic year.

Introductory courses, such as CS0/CS1 discussed inclusive design methods, presented one persona, and used self-reflection activities centered on the standard assignments for those classes. A dozen faculty members updated at least one existing assignment, with two faculty members updating two assignments. usually with an additional question for students, such as "Which persona would work well with this interface?" and explain why the persona was selected. Later courses considered more problem-solving methods and styles and their impact on users. Finally, students could use the full-inclusive design method to design and evaluate their senior projects. The Capstone student team weekly status report was updated with a space where students report if they had used GenderMag and how.

A follow-up faculty summer workshop was held in 2022. Faculty who joined the project fall 2021 or later took the free online GenderMag Education and Evaluator courses [22].

3.2 Research Questions

The research questions motivating this study were:

RQ1: (Faculty) How and to what extent do the educate-the-faculty workshops and curriculum affect how well faculty understand and teach equitable software design?

RQ2: (Feasibility) How and to what extent is the embedded equitable design curriculum feasible to use?

RQ3: (Student software) How and to what extent does the approach improve students' ability to design equitable software?

RQ4: (Culture) How and to what extent does the approach improve the inclusiveness culture for students in computing programs?

The goal was to investigate faculty experiences implementing inclusive design material into their existing courses.

3.3. Integration throughout the Curriculum

Utilizing the standard ABET CS/IT curricula, the curriculum included inclusive design methods in courses, as outlined in Fig.1. CS0, CS1, and data structures established the foundation, with junior and senior year reinforcement occurring in multiple required and elective courses, such as object-oriented development (OOD), web development, human-computer interaction (HCI), mobile app development, software engineering, project management, software engineering, and finally the capstone senior project course. CS0, CS1, data structures and senior capstone are required for all CS/IT majors, with pathways for CS or IT majors identified through OOD and software engineering (CS) or human-computer interaction and project management (IT) majors.

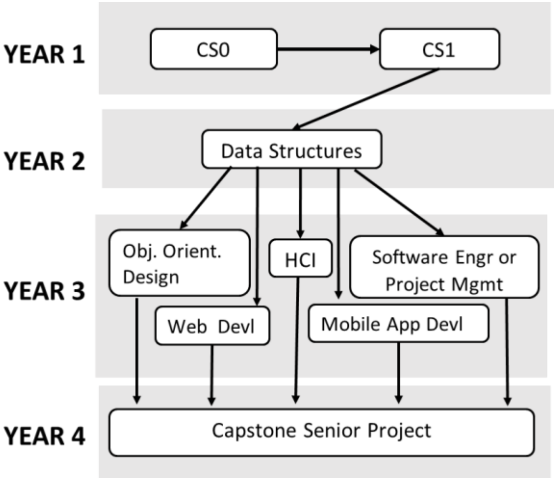

Figure 1: Core courses with inclusive design year-by-year

4 DATA COLLECTION

Semi-structured interviews with 9 of the 10 faculty members, who played an integral role in executing an inclusive design curriculum, were held in 2023. One faculty member was not available. Of the 9 faculty interviewed, 5 were male and 4 female. Each interview considered 21 questions and spanned 15-30 minutes on Zoom or in person. Examples of the questions asked include: 1)"Was incorporating inclusive design into your course minimally invasive?" 2)"How did you go about creating assignments with GenderMag elements?" 3) "How did you incorporate GenderMag elements within your courses?". The interviews were transcribed using Otter.ai [23]. Once transcription was complete, interviews were transferred to spreadsheets and segmented to identify questions and responses.

Table 1: Six codes were mapped to research questions, with faculty participant responses in a heat map

Code	Rule	RQ1	RQ2	R Q3	R Q4	P01	P02	P03	P04	P05	P06	P07	P08	P09
1	**Past Experience (Faculty)** Rule: Whenever the interviewee talks about past experiences	x					4	9	3	0	3	1	3	2
2	**Mgmt and Planning (Feasibility)** Rule: When segments talk about how something was planned or structured regarding GenderMag (+71/-24/21)		x						11					
3	**Faculty Experience (Faculty)** Rule: When segments mention how a instructor reacted to the incorporation of GenderMag into their course(s)	x				11		11	6				10	10
4	**Pos/Neg Reactions (Students)** Rule: When a segment mentions a reaction/something that was observed from the instructor(+31/-31:/0)	x		x		5							7	
5	**Future Plans (Culture, Faculty)** Rule: Whenever segment talks about future plans regarding GenderMag	x		x	x	2	4	3	2	1	3	3	2	3
6	**Additional Comments (Culture)** Rule: Whenever the segment mentions an instructor opinion				x	2	4		2		1	0		2

Interviews were coded based on a set of rules developed by the researchers after reviewing the transcripts, which assisted in dividing the segments into categories. The codes, respective rules, and mapped RQs 1-4 used for this analysis are highlighted in Table 1, where the darker cell colors indicate more responses received by the indicated faculty participant (P01-P09). Codes 2 and 4 were further categorized into positive and negative subsections. Code 2 received 116 references, with 71 positive, 24 negative, and 21 neutral. Code 4 received 74 references, with 31 positive, 31 negative, and no neutral references.

Two researchers conducted a coding test to achieve reliability and consistency. Using 20% of the total segments, each researcher read a segment and assigned a code(s) based on the rules in Table 1. The researchers then compared results and repeated the process until 80% consensus was reached in the coding by two researchers. This method gauges the code assignment agreement level between the researchers and assesses the inter-coder reliability.

5 RESULTS

5.1 RQ1: Faculty understanding of equitable software design

The educate-the-faculty workshops and the GenderMag methodology were designed to assist faculty members on inclusive design principles and techniques. The workshops and implementation of an inclusive design curriculum have positively impacted faculty members' understanding and teaching of equitable software.

Through these training programs, RQ1, supported by Codes 1 and 3-5 (Table 1), was positively supported by faculty members and a deeper appreciation for the importance of equitable design techniques and implementation in creating software that caters to a diverse user base was gained. The faculty workshops were vital in helping faculty understand and teach GenderMag. Faculty interviewee participant 4 (P04) said:

> P04: "[The workshops] help[ed] us learn GenderMag , but then also figure out for each of our specific courses, how to make the best use of it."

Through the integration of inclusive design approaches into their course development, faculty members can develop the capability to assess the accessibility and inclusivity of software systems critically. Additionally, their increased awareness of biases in software design encourages the development of course materials and assignments that reference GenderMag personas and prompt students to consider diverse perspectives and needs.

5.2. RQ2: Ease of use

To assess the feasibility of an embedded equitable design curriculum, faculty must adequately integrate inclusive design principles into their curriculum. Faculty updated one assignment in each of ten classes during the project. Updates in CS0 focused on informative error handling:

Some CS1 faculty asked students to consider if they and a partner were an Abi, Tim, or Pat as each persona has a different learning style, based on the GenderMag facets, and encouraging students to reflect on their learning styles:

P07: "[I] use the approach to have the students identify who they were [because if] they can't identify who they were, how are they going to recognize their partner? So I did try to soften the approach... I was happy with the way that it turned out. I think the students were empowered to create their [class] program software that reflected a diverse nature within the class."

In data structures, faculty had students begin coding a solution and then give it to another student for completion. A faculty member teaching web development commented that, for assignments where students created personal websites:

PO8: "It's a great activity, to work in pairs to switch websites with each other and be kind of not [just an] evaluator, but actually be like an Abi."

In the context of the student's learning style – for example, Abi learns new technologies if and when they need to but prefers to use methods they are already familiar and comfortable with.

Capstone faculty included a line on the student weekly status report where students could report if they had used GenderMag.

An assessment of the faculty interview shows Code 2, Management and Planning (Table 1), is where the faculty was the most vocal. Code 2 responses (Fig. 2) are categorized into four categories: *Lesson Plan*, *Student Interaction*, *Practice*, and *Revisions,* which are detailed here.

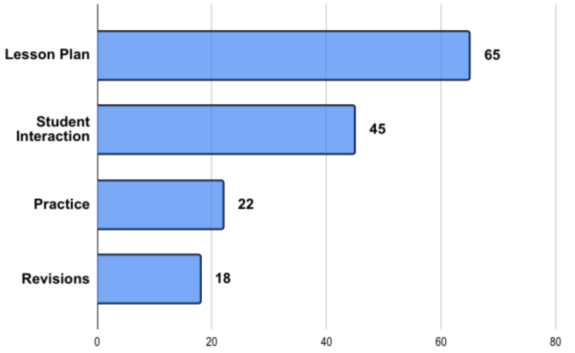

Figure 2: Code 2 responses by topic grouping and frequency

5.2.1 Lesson Plans. Educating-the-educators workshops allowed instructors to collaborate with colleagues who teach the same course and revise assignments used in the curriculum. The development of the assignment is a crucial aspect, allowing students to practice implementing inclusivity within software designs. Once the initial assignments were created, faculty shared them with their colleagues**,** who revised the material before implementing it into their curriculum.

P03: "I developed it while we were in the workshop with P02. We are working together so that we are in sync. Now I am sharing with new professors."

Another respondent, when asked "Are the assignments in our course adopted from another professor?" states:

P01: "Yes. It was a course taught by another professor before I joined the department. I have made updates to it regularly. I make little adjustments here and there."

The faculty agreed that implementing inclusive design within their curriculum is minimally invasive, as they modified assignments very little and use the same grading rubric for assignments with inclusive elements and without.

5.2.2 Student Interaction. Faculty utilized real-world examples to raise awareness about inclusivity bugs within the students.

P03: "Giv them an example. Like, whoever is using the application that you're writing for could be [a family member] or stuff like that. How would you do it?"

5.2.3 Practice. During the educate-the-faculty workshops, faculty worked together in breakout rooms, taking turns practicing teaching lessons to each other. Faculty who took the online GenderMag training said they had also practiced the method before using it with students.

P06: "I [completed the]... gender mag educator training. And it's very helpful. The materials and the kind of activities during the training were very helpful. So as an educator, it's very informative and useful for me, especially in preparing my course materials to make it more user-friendly, especially the different types of design catalogs."

P09: I gave them some slides about GenderMag personas. And I practiced with the students in the class, in the lab sessions, and to teach them to identify their own personas and think "in" the personas, how they will handle those things when they start in different personas. So, I add[ed] those things into my classes and lab sessions to the students."

5.2.4 Revisions. A concern highlighted in the interviews was related to student consent forms. Collecting student consent in each course is tedious and results in multiple consents from the same student. To avoid this, one consent per student was recommended in the future. Faculty also revised their courses, updating the GenderMag assignments as they became more familiar.

5.3. RQ3: Students' ability to design equitable software

Implementing an inclusive design curriculum aims to improve students' ability to design equitable software. This approach aims to sensitize students to biases that may be present in software so that they become more aware of potential gender-related issues, accessibility concerns, and other biases that may emerge inadvertently during the design process.

RQ3, supported by Codes 4 (student reactions +/-) and 5 (future plans) (Table 1), was positively supported by all nine of the participating faculty who were interviewed. When asked, *Do you feel that students adapted to this new way of thinking (i.e.,* *writing inclusive and accessible code)? *based on assignments without GenderMag elements vs assignments with GenderMag elements*, all nine faculty members agreed that they have seen students actively use inclusive design elements that they have been taught even when not prompted. The readiness of students to include these elements was noticed:

P07: "I did notice that the students were prompted to consider their diverse needs and they actually looked at the different perspectives of users. And this seemed to create a more inclusive software."

Through faculty reinforcement and continuous exposure to the GenderMag approach, faculty reports indicated that students could integrate inclusive design principles into their software development.

5.4. RQ4: Inclusiveness of the culture for students

Faculty respondents have stated that this inclusive approach has allowed students to develop software from the perspective of the users, an outside-in approach to building software. Faculty also stated that they will change how inclusive design methods are introduced to students for increased student engagement.

P09: "I gave them the assignments very late after the midterm. Next time at the beginning, I will tell the students the importance of inclusive design and engage them. I will add [details] to increase their participation rate and lead them to understand the importance of these things."

Two faculty members also state an approach that can be taken to improve the inclusiveness culture for the students. Respondent P01 mentioned once students have designed their application, a student who does not have CS or IT background should be the tester and conclude if the application implements features that target a diverse community. P08 mentioned that inclusivity should be integrated into artificial intelligence (AI), allowing a diverse community to use the software effectively.

6 CONCLUSION AND LESSONS LEARNED

Faculty noticed that students were including personas and using inclusive design methods without being prompted in upper-level courses, such as Senior Capstone:

P04: "The good thing is when I see in a handful of projects, … in the presentations and the reports, that [I] actually … saw actual effort or work put into say, Yeah, they did think about their persona differently and [were] impacted. And they talk about it and explain how it impacted their design".

This is an important observation because the Capstone course is an independent project where students can choose and create their own semester-long project with limited faculty input. Despite students' free reign over the project, all Capstone faculty observed that most students actively incorporate inclusive design and consider who their users are when building their software.

Based on faculty interviews, it was also noted that the faculty themselves were impacted. Faculty reports indicated that awareness was increased, affecting how faculty viewed student work, graded it, and gave feedback. A Capstone faculty member explained:

P05: "One group had designed a game. It was called… it had the word, man, so it was like ice cream man or something like that. And I suggested that, you know, … why don't you rename it? And they renamed it to 'Galaxy Cone'."

Logistic lessons learned include future plans to reduce the repetitive ask for consent forms. During each semester, undergraduate research assistants visited the class sections of participating faculty to obtain student consent, 15 sections in the fall and almost 40 sections in the spring. Many students were asked to sign the consent form more than once, as they were registered in multiple participating sections. The research team will adopt the faculty suggestion to get student consent once for the semester.

Pedagogical learning included:

- *The faculty need time to learn the intervention and design the materials that will be used for classroom instruction.* The initial summer workshop of 4 half-days was adequate. Faculty occasionally touched up their materials in subsequent semesters.
- *The collaboration model established in the faculty workshops continued throughout the research project,* with faculty discussing GenderMag assignments informally, particularly among CS0 and Capstone faculty.
- *The implementation was regarded as easy to integrate into the classroom and grade,* meeting the research goal of not being invasive to the standard classroom experience.

Regarding negative responses collected during the interviews with faculty, two main issues stood out for the faculty.

- Some students began showing displeasure when GenderMag was mentioned. The students are believed to associate GenderMag with extra work or repetitive requests for consent in each class rather than once for all classes.
- A few faculty who taught the lower-level classes struggled to integrate inclusive design material into their courses. They did not see the relevance of gender-inclusive design principles in introductory classes at first, initially believing such topics are more suitable for advanced or specialized courses.

Overall, using GenderMag to teach inclusive design methods throughout the entire four-year ABET CS/IT curriculum was demonstrated to be a low-cost, high-return intervention that improves student awareness of the importance of inclusive software design and provides students with opportunities to practice inclusive software development. Faculty use of inclusive software design methods throughout the undergraduate curriculum should continue, ensuring that the next generation of computer science and information technology graduates have the skills to build inclusive software.

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