Education Tech Research Dev
https://doi.org/10.1007/s11423-023-10292-3

RESEARCH ARTICLE

Girls Design with Code Club

Adam V. Maltese[1] · **Kelli M. Paul**[1] · **Bárbara Yarza**[2] · **Lauren Penney**[1]

Accepted: 11 September 2023

Abstract
In this manuscript, we describe a coding club we created and implemented during the COVID-19 pandemic. We were purposeful in creating the club to: (a) focus on design and problem solving as the basis for learning computer coding and (b) include elements to improve the engagement of girls. We ran multiple iterations of a Girls Design with Code Club that involved over 100 girls from 22 countries. We reviewed various sources of data to evaluate how our design and implementation of the coding clubs impacted the girls who participated. In an effort to share our learnings with other researchers and program providers, we share evidence of choices that we believe had positive impacts and others that we can improve in future iterations.

Keywords Design · Coding · Gender · Making · Problem solving · Online education

Introduction

In this project, and our work more broadly, we seek to reduce inequities in maker and STEM education, many of which were exacerbated during the COVID-19 pandemic. We situate this project in maker education, where a frequent mantra is that *anyone can be a maker*, as exemplified in, "The present narrative is that anyone can and should have access to the tools and knowledge necessary to build anything they might need or want" (Rosa et al., 2017, p. 4). However, critics caution that making often falls short of this ideal and caters primarily to white, middle-class males with no accessibility issues (Buechley, 2013; Halverson & Sheridan, 2014; Martin et al., 2018; Seo, 2019). Similar issues also exist in STEM fields in the United States where there continues to be underrepresentation of women, individuals from non-White/non-Asian racial and ethnic groups and those with disabilities (NCSES, 2023). Beyond lack of representation, these groups continue to experience marginalization in various aspects and levels of STEM education (e.g., Chakraverty, 2022; Wilkins-Yel et al., 2022; Xavier Hall et al., 2022). These issues are particularly entrenched in computing, where women make up ~ 25% of the workforce (NCSES, 2023) and discrimination of women in tech is regularly in the news (e.g., Chang, 2019; Grant,

✉ Adam V. Maltese
amaltese@iu.edu

[1] Indiana University School of Education, Bloomington, IN, USA

[2] Universidad Autónoma de Baja California, Mexicali, Mexico

Published online: 23 October 2023

2022; Lapan & Smith, 2023). While inequities in access to computing resources (e.g., hardware, internet access) existed pre-pandemic (Irwin, 2021), the massive shift to online learning exacerbated these situations, particularly for females, rural students and those from low-SES contexts (An et al., 2021; Kennedy et al., 2022; Muñoz-Najar et al., 2021).

Program Background

This work developed out of our CoBuild-19[1] project that started early in the COVID-19 pandemic to provide maker activities for families to do while on travel restrictions (Maltese et al., 2022). As the pandemic continued into summer 2020 we extended our original offerings to include coding. Originally, we had not included programming or electronics activities in CoBuild-19 activities because we knew access to microelectronics and platforms to code them were barriers to many of the young people we sought to engage. Unfortunately, we could not overcome all the barriers to access described above. However, in an effort to reduce them, we leveraged the free online block coding interface and simulator for the BBC micro:bit via the Microsoft MakeCode platform.

We structured *Design with Code Club (DwCC)* to be different from other common coding offerings (Erol & Çırak, 2022; Kalelioğlu, 2015) in that we wanted the main focus to be on kids designing solutions to problems that might leverage the affordances of technology and coding (e.g., Fee & Holland-Minkley, 2010; Gennari et al., 2021). We were purposeful in this decision for two main reasons. First, we wanted this effort to be inverted from other common programming instruction, where coding activities use programming as the core of instruction and application in authentic and student-selected contexts plays a secondary role (Rich et al., 2019). Second, we sought to make our coding club more interesting to girls in an effort to establish gender parity in the club. Previous research provides evidence that girls demonstrate a strong interest in designing solutions to problems with a social impact (Miller et al., 2006). Additionally, research supports that: (a) social isolation is problematic for minoritized women in computer science (Rankin & Thomas, 2020), and (b) increased interest in computer science is positively associated with technological curiosity and perceived support from peers and teachers (Denner, 2011).

With these instructional goals in mind, in each DwCC we intentionally incorporated and aligned activities that focused on: (a) the engineering/design (e.g., Sung & Kelley, 2019), (b) basic ideas of programming and computational thinking, and (c) open-ended and socially-oriented design challenges. We used the virtual micro:bit simulator through Microsoft MakeCode as our main instructional tool (Fessard et al., 2019). Since simulations are not as enticing as physical computing with a tangible device, we set up an incentive where youth who participated in at least three sessions of the club would be shipped a physical micro:bit device. Funds from our grant allowed us to pay for these devices and ship them to participants.

In this paper we describe our iterative development of the Design with Code Club through three versions—with explicit focus on two versions that had the specific intent to engage more girls in computer programming. The initial version began with the instructional design goals outlined above and these were iteratively modified to facilitate a supportive learning community for our targeted populations. Despite extensive planning and

[1] Project activities can be found here: https://cobuildathome.com/.

discussion by instructors prior to each club, which focused on creating an inclusive learning community, we did not explicitly document design decisions or formally keep track of best practices. Thus, our goal in this paper is to explain our design iterations, identify practices we believed were useful in fostering participant engagement and community building, and suggest ideas for future exploration.

Design with Code Clubs format and revisions

The initial Design with Code Club (DwCC) was designed to include 6 one-hour sessions where instructors and participants met synchronously on Zoom. Participation was open to childen (both boys and girls) in the target ages of 11–14 years old, though we did not exclude children outside of this age range. The first version of DwCC was set up so that each of the first 4 weeks included a different larger challenge that had some connection to COVID-19. Sessions usually started with some introduction to a design or computing concept, followed by a group activity, and some coding instruction that would introduce and explore micro:bit capabilities through smaller design challenges. Each session ended with instructors proposing a design challenge that utilized the skills and features participants learned of in previous activities. Participants were asked to share their solutions and code to the weekly design challenges via the Flip (formerly Flipgrid) platform. Within Flip, participants and instructors could comment on and ask questions of others in the group. DwCC culminated with an open-ended project where the participants were challenged to come up with their own problem for which they might incorporate micro:bit as part of the solution. To facilitate this, we changed the format of the sessions for Weeks 5 and 6 substantially to allow participants to spend time engaged in thinking about design, brainstorming ideas and trying to troubleshoot issues with their plans or programming. For the final project we split the "homework" tasks into two parts: (a) problem identification, brainstorming and initial solution ideas and (b) attempted solutions and reflection.

After a successful first iteration of DwCC, we sought to expand the effort and increase accessibility for groups that are traditionally underrepresented in STEM. In spring 2021, we offered a Girls DwCC (GDwCC). Our hope was to create a program where young girls could learn about and use technology to solve problems in an environment where their backgrounds and experiences would be welcomed and celebrated. With one of our original facilitators from Mexico leading this version, and since the pandemic had an extensive global impact, we also thought it would make sense to offer this training to anyone who was interested. Because of this broader focus we sought out facilitators who could provide a diverse range of perspectives, backgrounds and languages. Three women facilitated the second iteration of GDwCC, including an educator from the United States, an Industrial Engineer from Mexico and a computer programmer from Albania. More than 70 girls from 17 countries and 18 US states participated in this version of the club.

In the first GDwCC, we had a number of girls participate for whom English was not their native language—including a number of girls with Spanish as their native language. Since Latinas are a group that is traditionally marginalized in STEM and since we had access to instructors who could facilitate this content in Spanish, we decided to create another version that would be offered in Spanish and focus on Latina girls in the US, Mexico and Central and South America (the Latina GDwCC). The Latina GDwCC was run by the Industrial Engineer from Mexico who ran GDwCC and another female educator from Mexico who had extensive experience teaching with micro:bits. Within a few days of announcing the club through social media and through educator networks, registration

quickly rose to 270 individuals before we closed the registration process. Anecdotally, we were told that these types of programs are not common in many of these countries which likely drove the high amount of interest. More than 90 girls from 10 countries participated in the Latina version of the club. See Table 1 for more details on the GDwCCs.

When we started the CoBuild-19 project we connected many of the design challenges to pandemic topics, which we continued with our first iteration of DwCC. More than a year into the pandemic our team felt that continuing to focus content on the pandemic would potentially exacerbate feelings of anxiety and separation kids were feeling. Thus, instructors for GDwCC sought to shift the focus of the challenges away from topics related to COVID-19 to others focused more on the personal lives and experiences of the participants and placed even more emphasis on problem-solving through design. Instructors also incorporated activities designed to increase participation and engagement and build community. For example, "unplugged coding" activities were included that involved activities to reinforce key coding concepts but in fun, interactive ways that did not utilize the MakeCode interface. GDwCC also made direct connections to women in STEM. As one example, instructors offered an optional activity/contest ("Seeing Double") where girls were challenged to recreate a historic photograph or artwork related to the history of women in the computer sciences by using themselves and objects found in their home (Fig. 1). Submissions included a presentation of their creation via video on Flip where they provided additional explanation (e.g., who or what the work was about, why it was special, what you discovered in the process, etc.).

Instructors for the Latina GDwCC kept the noted changes and also added an element to showcase Latina women in STEM. To do this, facilitators invited Latina women in STEM to create a profile (on Flip) where they weekly shared about their careers and personal experience in STEM and viewed and commented on videos posted by the girls. Additionally, one speaker was invited to attend a live session where she talked to and interacted with the girls, which led to a lively question-and-answer session.

Interactive design elements

Synchronous club sessions for GDwCC were similar to the original DwCC sessions—the main meetings were one-hour Zoom meetings held weekly. The sessions also had a similar format and level of content to the DwCC. During sessions, girls could ask questions or comment verbally or by using the Zoom chat function. Having multiple instructors in each session allowed one instructor to lead activities, while the other(s) helped answer questions and address comments or troubleshoot technical issues in the chat. Unlike typical coding clubs that are offered in person in a singular physical location (e.g., in or after school clubs), our clubs occurred entirely virtually. As such, we sought to extend interaction and community-building efforts beyond the weekly Zoom sessions.

Email communication was vital to communicating with participants before and after club sessions. Emails were sent to participants prior to the first session with information about the GDwCCs, including how-to videos, log-in information to Zoom and Flip, the link to all course materials, and contact information in case there were questions or technical difficulties. Following each session, instructors sent another email that contained a review of the previous session (including class slides and recordings of the session), information on upcoming projects, reminders, etc.

As mentioned, for each club we set up a Flip community for participants to use to interact with each other and the instructors between Zoom sessions. Flip is a video discussion app that

Table 1 Content coverage and participation for both Girls Design with Code Clubs

Session	Topics > Content > Challenge	Additional activities	Approximate attendees (Challenges completed)	
			GDwCC	Latina GDwCC
1	Algorithms > Inputs, LEDs, Icons > Emoji Challenge	Latinas in STEM [L]	70 (55)	90 (67)
2[a]	Sensors & Variables > Variables, light, compass, temperature > Sensing the World Challenge	Seeing double contest [G]	70 (39)	80 (53)
3[a]	Variables & Music > Variables, Loops, Melody, Tempo, Volume, Tone > Remix Challenge	Unplugged coding—Dancing [G & L]	60 (41)	80 (47)
4	Logic > Conditionals, booleans, random > Video Game Challenge	Unplugged coding—Guess who? [G & L]	50 (27)	75 (41)
5	Accessibility > Human Centered Design and Problem Solving > Accessibility Challenge	Empathy map [L]	40 (20)	60 (39)
6	Radio & Multi Editor > Send and receive > Share Your Experience	Gratitude and learnings activity [G & L]	40 (13)	60 (28)

G GDwCC, *L* Latina GDwCC

[a]Weeks 2 and 3 were switched for the Latina GDwCC

Fig. 1 Prompt (top) and results (bottom) for the *Seeing Double* creative contest

allows members of a group to share and view videos, providing a place for peer discussions. Girls were encouraged to post their projects each week to Flip as well as to view and provide comments, reactions and feedback to the videos posted by other girls. Flip also was used to provide video tutorials to help with MakeCode, ask questions and get technical support. These strategies and tools (Zoom, email, and Flip) helped us build a supportive and inclusive community.

Methods

We made numerous design choices in the coding clubs with the goal of making a more equitable and interesting offering for kids. For the current study, we focus on the two Girls Design with Code Club iterations. Both iterations sought to encourage engagement and foster the development of community among girls. However, we did not identify these best practices a priori. Rather, our goal in this paper was to identify the practices we believed were useful in fostering participant engagement and community building in order to suggest ideas for future exploration. To accomplish this, we followed a grounded theory approach using inductive open coding to identify the practices used in the GDwCCs.

Participants

We advertised the initial DwCC through social media platforms, primarily via our group's Facebook feed and those of other pandemic-related groups (ASEE P12 Instructors and Parents, ISTE Librarians Network, K-12 Learning Possibilities in Pandemic Times, Oklahoma Public School Pandemic Teachers, Teachers Who Love Science, etc.) and across listservs we engage with that are for maker educators across the United States. Those announcements included a link to a survey that interested caregivers could complete to register their children for the club. These surveys collected some background data about the participants, with other pieces of information collected throughout the club sessions.

For the first edition of GDwCC, we implemented the same strategy as in DwCC. The most remarkable change was having facilitators from different countries spread the word with their communities and networks. For the Girls Design with Code Club Latina Edition, we advertised in Spanish and English language across Facebook groups specifically related to education, tech opportunities for girls and STEM education, targeting specific countries in Latin America (Chile, Mexico, Colombia, Ecuador, etc.). We also created a GDwCC Instagram profile and connected with Latin educators to share with their communities.

Girls Design with Code Club

We had 106 girls enroll in the club, with 70 participating in the first session and 40 participating in the final session (Table 1). Of the youth participants, 99% identified as girls—but we made it clear that anyone was welcome to register for the club. We will use the term "girls" to identify the participants in these clubs throughout the rest of the paper. These girls ranged in age from 8 to 17 ($m = 10.8$ years) and across grades 1 through 9 (mode = 5th grade). Also, 15 teachers registered for the club. Participants represented 15 countries (Albania, Australia, Brazil, Canada, Colombia, Costa Rica, India, Italy, Kenya, Kosova, Maldives, México, Morocco, Romania, Rwanda) and 16 states from the US. We had 3 women facilitators, from México, Albania and the US. The course instruction was offered in English, but one facilitator also spoke Spanish and another spoke Albanian.

Participants were asked to complete six activities and one optional creative challenge throughout the program (see Table 2). For the creative challenge, five girls and one teacher participated. Fifty-four percent (38/70) of our participants completed at least three of the club activities, which qualified them to receive a micro:bit, GDwCC t-shirt, and digital certificate of completion.

Table 2 Submissions for both Girls Design with Code Clubs

Completed/submitted	Percent of participants who submitted at least once	
	GDwCC $n=50$	Latina GDwCC $n=67$
One activity	14%	25%
Two activities	9%	10%
Three activities	18%	9%
Four activities	18%	10%
Five activities	30%	13%
Six activities	11%	3%
All activities and final evaluation	n/a	28%
Optional creative challenge "seeing double"	13%	n/a

Latina Girls Design with Code Club

We had 277 participants register for the Latina edition of the GDwCC with approximately 90 girls attending the first session and 60 girls attending the final session (Table 1). For 259 (93%), Spanish was their native language. We had 68 active participants throughout the program's synchronous and asynchronous activities, 65 (95%) of whom were native Spanish speakers. These girls ranged in age from 8 to 17 ($m=11.4$ years) and across grades 1 through 9 (mode = 5th grade). Participants represented 10 countries (Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, México, Panama, Peru, Puerto Rico and the United States). Also, 3 teachers participated in the club and we had 2 women facilitators from México and 5 mentors from the U.S. (2), México (2) and Uruguay (1).

Course instruction was offered in Spanish. Participants were asked to complete six activities and one evaluation (see Table 2). The requirement for qualifying to receive an incentive for participating was to complete at least one activity on Flip to receive a digital certificate. In order to also receive a club t-shirt, girls needed to complete five total challenges with results shared on Flip, complete the end-of-course survey, and create a video about their experience in the club. Overall, 24 participants received incentives. Unfortunately, due to global shortage of available micro:bits, general challenges with shipping within Latin America, and the high number of girls registered for the Latina GDwCC, we were not able to offer girls in this club a physical micro:bit, as we did in DwCC and GDwCC. However, they could earn a GDwCC t-shirt and a digital certificate of completion.

Data and analysis

We collected multiple forms of data for this project, including: planning documents and materials, survey data at the time of registration (from caregivers), post-participation surveys and interviews, videos and transcripts from club sessions, and student-submitted videos presenting their "solutions" to the weekly challenges that were posted to Flip each week. The analysis for this paper primarily focuses on the videos of the club sessions for the Girls Design with Code Club (GDwCC; spring 2021) and the Girls Design with Code Club Latina Edition (Latina GDwCC; January/February 2022). However, we also utilized

planning documents, instructional materials, instructor reflections, and the Latina GDwCC post surveys to supplement and better understand the findings from the video sessions.

Analysis

We utilized a grounded theory approach using inductive open coding to identify practices used during the clubs that fostered participant engagement and community building (Corbin & Strauss, 1990; Strauss & Corbin, 1990). We did not enter analyses with an a priori list of best practices; rather, the researchers who coded the videos were unfamiliar with the specific instructional practices and design choices made for the GDwCCs. Two researchers (the 2nd and 4th authors) watched at least three videos each from the GDwCC and Latina GDwCC, noting practices observed and identifying them with a descriptive label. Using thematic analysis, the researchers grouped the practices into broader categories (Braun & Clarke, 2006), identifying four categories of practices that were used to encourage engagement and participation and to foster the development of community among girls. These categories are: (a) access to materials and information, (b) creating a community, (c) learning that is active and relevant, and (d) cultural background and language. Table 3 presents the codebook of practices we identified and categorized. We collaboratively discussed the identified practices and definitions. We then used this codebook to independently code the first session of each GDwCC, discussing and refining codes as we identified additional practices or modified our definitions of existing codes and categories to encompass the practices across both GDwCC and Latina GDwCC. Once we came to a consensus on the codes, a third researcher (third author) was trained on the codes. The three researchers independently coded a sample of videos across the GDwCCs. Of the six sessions for each club, #1, #2, and #4 were thoroughly and iteratively coded. These three sessions were selected as they allowed us to see how these practices were developed and how they continued or others emerged. Other videos were reviewed but not coded. The 2nd and 4th authors coded the GDwCC videos, and the 2nd and 3rd authors coded the Latina GDwCC videos. Each researcher coded their respective videos to identify instances of these practices. Multiple practices could be coded simultaneously.

Analyses of planning documents, instructional materials, and instructor reflections consisted of one researcher reading through these documents and noting when instructors described or mentioned instructional practices. Post-surveys from the Latina GDwCC version were analyzed using descriptive statistics with open-ended items being coded for themes similar to those in the video sessions. These data sources were used to triangulate and better understand the themes identified in the video sessions. In the analyses, we focused on finding and reflecting on practices that encouraged engagement and participation of girls and that fostered the development of community among the girls. Some of these practices are ones that we would want to continue in future iterations and some highlight areas where we missed the mark and could have done better. It is also important to make clear that the "perfect" lesson is ideal and unattainable such that even the most experienced educators will not make the perfect pedagogical choices 100% of the time. While we present these practices as missed opportunities, we are not making a value judgment about the instructors but instead raising them as issues for instructors to consider as they plan and implement similar opportunities for youth in the future. Our results highlight a number of practices utilized and provide a sense of the various types of practices used during the GDwCCs.

Table 3 Frequencies of pedagogical practices and design elements by club

Pedagogical practices and design elements	Example	GDwCC (*n* = 118)	Latina (n = *140*)
Access to materials and information		49	40
Multiple communication channels	Mentioning where/how can facilitators and girls can communicate; Noting and Using multiple ways to communicate	8	8
Resources available online	Mentioning slides and other information will be shared and available online; Session videos recorded and available for later review	10	7
Addressing questions in the moment	Recognizing questions; answering them	29	18
Large group sizes limits engagement	Mentioning not being able to get to all questions	2	7
Creating a community		27	34
Interactive activities	Ice-breakers; asking questions and letting girls brainstorm together; Involve some aspect of getting to know each other or working together	4	5
Watch/comment on each others' Videos	Mentioning FlipGrid videos	6	6
Celebrating each other	Celebrating accomplishments in club or personal lives (e.g., birthday)	7	5
Community of learners	Mentioning using each other as resources	3	6
Design mentors	Mention of or direct interaction with women or professionals in coding, CS, etc	0	1
Creating connections	Making direct connections with girls, their interests, etc	3	9
Building community	Welcoming girls to sessions, talking with them	5	0
Learning that is active + relevant		14	19
Fun/active activities	Unplugged dance activity or guess who game; encourage active participation	0	2
Contests/incentive	Mentioning earning micro:bits; contest	5	1
Women in STEAM	Connecting to women in STEAM	3	4
Tying coding instruction to design and girls' lives	Making instructions relevant to girls' lives (or missed opportunities to do so)	7	11
Giving potential use cases throughout direct Instruction	Connecting cases or topics to instruction (or missed opportunities to do so)	0	1
Cultural background and language		9	7
Recognizing barriers	Mentioning English not being the first language	3	1
Recognizing culture, language & background	Noting cultural background or girls; Mentioning or using Spanish or native language	6	6

Results

Analyses were conducted separately for each club due to minor differences in club activities across the sessions. Coding generated 118 and 140 instances of practices across the three GDwCC and Latina clubs, respectively. Across both clubs, the majority of practices related to providing Access to Materials and Information, followed by Creating a Community. A variety of sub-practices were identified for each category of practices, with some used more frequently than others. Table 3 presents the practices and sub-practices identified in the two clubs. The percentage for each practice is the number of coded instances for that practice across the entire corpus of instances coded. We provide examples of these practices from both GDwCCs, as relevant, using pseudonyms for all instructors and girls.

Access to materials and information

Across both clubs, the practice most often identified was providing access to materials and information. Instructors utilized instructional practices that provided open access to themselves, course materials, and other resources to the girls throughout the GDwCCs. These practices included the use of multiple communication channels to support interactions and sharing of information as well as posting course materials for later review by girls. Both practices encouraged participation and engagement by the girls.

The GDwCCs provided multiple communication channels between participants and instructors—during and between the weekly sessions. Instructors encouraged girls to send comments or questions to them during Zoom sessions via chat, raising their Zoom hand and/or unmuting their microphones and speaking up during the session. Between sessions, girls could post videos to Flip that not only showcased their projects but where they asked questions or shared coding problems they faced. Finally, email was a vital channel for communicating with instructors utilizing it as a two-way channel where instructors provided information and where girls could seek help. Instructors emphasized that they were there to help girls and encouraged them to reach out in whatever manner was easiest for them, with one instructor commenting:

> Whoever is facing some issues, just feel free to email us or upload a video on the questions section at the Flip or ask for help for other girls, so let's have this team spirit, don't be shy if there is something you are struggling with or you haven't understood very well, so just ask. (*Susane, GDwCC Instructor*)

Videos, slides and other materials and resources were posted online for girls to be able to access before, during, and after weekly Zoom sessions. The GDwCC utilized a persistent website where all course materials were hosted, while the Latina GDwCC utilized a shared Google Drive as instructors found that it provided easier storage and access for themselves and the girls. During weekly sessions, instructors reminded girls that it was okay to miss a session, be late or leave early; acknowledging that they were aware of scheduling conflicts and technical difficulties that might prevent girls from logging on live. This was particularly relevant given that there were participants from across many time zones. Instructors showed girls where materials were posted and encouraged them to access the videos and slides from each session along with other helpful videos about logistics and topics.

While instructors provided multiple channels of communication and access to resources and materials, they faced challenges with addressing questions in real-time during Zoom

sessions. Large group sizes in both GDwCCs made it difficult to engage with every participant during the sessions, especially with some girls speaking often and others not at all. Because so many girls were logged on for each session, instructors periodically reminded girls to mute their microphones so that everyone could hear the instructions. The post-survey for the Latina GDwCC provided further evidence of this challenge with a few girls commenting about issues with the large group size (e.g., microphones being on, difficulty with hearing clearly, not able to control the chat and wanting it only for questions, etc.). Large group sizes also made it difficult to address questions in the moment as there simply was not enough time to answer all questions and provide the instructions needed within the one-hour session. In some instances, girls asked questions, but they were told to hold these until the Question & Answer portion of the session or to remain logged on after the session ended to talk with instructors individually. This illustrated the common pedagogical tension between needing to move ahead with instruction for the larger group while also answering questions that prevented individual girls from keeping up with the material. Instructors tried to address this challenge by having multiple instructors present during each session, which allowed girls to utilize the chat to get questions answered during instruction. However, some girls may have felt like they were not heard or left behind while having to wait for answers.

Creating a community

The second most identified category of practices related to efforts to create a sense of community among participants. The GDwCCs occurred entirely virtually, so creating a feeling of belonging posed a challenge with girls attending from all over the world. Instructors employed multiple approaches to build a sense of community among the girls. First, instructors tried to learn about girls through interactive activities (e.g., ice-breakers such as Zoom polls and games) during Zoom sessions and through what girls shared with them via their videos. Instructors then used this information to connect with and celebrate the girls during the live Zoom sessions. For example, in the Latina GDwCC, instructors recognized girls who celebrated birthdays during the weeks of the program. Similarly, in the GDwCC, when a recent birthday was mentioned in the chat, all three instructors congratulated the girl, Rosa, and celebrated her with a special shoutout, as exemplified in the following exchange:

> Juliana: Quickly, in the chat, I saw that Rosa had a birthday yesterday, so Happy Belated Birthday, Rosa! I hope you had a great time celebrating.
> Rosa: Thanks.
> Andrea: How old are you now?
> Rosa: 10.
> Susane: Wow, you have accomplished 10 years! That's a very important and beautiful number, so congrats to you. Many more cheerful years to you!
> Juliana: Yes, and welcome to the double digits!
> [Laughter from Susane & Andrea]

A sense of community was fostered by the girls and instructors interacting with one another outside of the weekly sessions via Flip. Multiple times during the sessions, instructors encouraged girls to post their videos as well as view and comment on the videos of at least three other girls. The instructors also made efforts to watch and comment on all the videos, telling the girls to let them know if they did not receive a comment:

> All right ladies, I have a quick announcement and I'll remind you all at the end of the session, we want to ensure that everyone's videos for challenges for week 1-3 have been commented on, by either myself, Miss Andrea or Miss Susane. So sometime tomorrow or Monday, please shoot us an email if we have not commented on one of your weekly challenges… We want to make sure we are giving all of you ladies feedback. I have had the opportunity to review everyone's videos and I think you ladies are doing an outstanding job …I think we are looking at the next group of computer scientists, computer engineers, biomedical engineers, scientists…So again, shoot us an email if we have not commented on one of your videos. *(Juliana, Instructor - GDwCC)*

In the Latina GDwCC, the community extended to the Latina mentors in STEM who also viewed and commented on videos via Flip and via the chat during Zoom sessions.

Girls were encouraged to be a resource for and to learn from each other by communicating with one another and commenting on the videos posted on Flip. Instructors encouraged girls to include the link to their MakeCode when sharing their videos on Flip so that others could see the blocks and coding they used as it would help everyone to better understand their projects. By doing so, they could become a community—learning with and from each other. Additionally, after the GDwCCs, one instructor reflected that, "Girls lift other girls up!", further noting that in several cases, "When someone asked a question in the chat, participants were open to help and give support."

Finally, instructors encouraged girls to stay in touch after the clubs finished and continue building their communities. Andrea commented that the instructors had talked with one another about how they wished they had the opportunity to participate in an experience like GDwCC (when they were kids) with such a diverse group of girls from around the world. She went on to encourage them to stay in touch, saying: "So having the opportunity of connecting with girls that like the same topic as you, that are very creative as you, it's a great opportunity. Please stay in touch and share with each other and maybe one day you will be working with each other!".

Despite extensive efforts to build community, analyses of the instructors' reflections suggest challenges with doing so. They acknowledged that they tried to make Zoom sessions more about sharing and group participation than providing direct instruction. At the same time, they felt that it was difficult to balance explaining, troubleshooting, unplugged activities, and conversations with the girls in the timeframe of weekly one-hour sessions. Using Flip presented additional challenges. Instructors noted that some girls were hesitant to post videos, especially if the video showed their faces. Other girls had trouble recording video or audio due to the equipment or browsers they were using. While instructors were successful in being able to troubleshoot many of these technical issues, these barriers did hinder some participants from fully participating in the Flip community space (Instructor Reflection Notes).

Active and relevant learning

Another common practice was to incorporate a variety of active and relevant experiences into the GDwCCs to encourage participation by the girls. These included providing fun/active activities, contests and incentives, and showcasing women in STEM and CS careers.

Instructors tried to make the weekly Zoom sessions about more than just instruction, incorporating playful, active games or activities whenever possible to help girls be more actively engaged and to reinforce the coding concepts in "unplugged" ways (e.g., Battal

et al., 2021). For example, Zoom polls included questions about girls' interests and preferences, sometimes including "Would you rather….?" type questions for girls to answer. These served dual purposes in that they also helped build community as girls learned about one another. Additionally, instructors led multiple unplugged activities that did not utilize MakeCode, including one that taught girls about variables by having them get up and dance along with specific types of dance moves (e.g., disco, freestyle, etc.) when a particular variable appeared on the screen. Girls helped explain dance moves to other girls who were less familiar with them and smiles were apparent as they danced along with instructors. As that session ended, one girl called out an instructor who said she would dance later but had not yet done so, to which the instructor commented the girls had "good memories", ultimately dancing along with them before the session ended.

Both GDwCCs utilized contests and incentives to encourage continued participation in the weekly sessions and challenges. As mentioned, we set up an incentive where girls who completed at least three challenges would receive a prize consisting of a physical micro:bit, a GDwCC t-shirt, and a digital certificate of completion. However, due to micro:bit shortages during the Latina GDwCC, we were not able to provide micro:bits as an incentive for girls participating in that club. Instructors noted in their reflections that having the incentive of "complete the program and you'll get a microbit" played an important role in retaining girls from different countries, especially those who don't have access to a lot of tech materials for education. As described earlier, instructors provided girls in the GDwCC the opportunity to participate in an optional contest ("Seeing Double") to earn an additional small prize. Although instructors noted that few girls chose to participate, the girls who did "were really engaged and did a really creative job" noting that the activity provided a "fun way to explore and learn" as the girls were interested in what others shared and about women across cultures (Instructor Reflection Notes).

Instructors in both GDwCCs were intentional about making direct connections to women in STEM. In the Latina GDwCC, the instructors specifically highlighted the role of women in STEM and Computer Science. They provided examples of women in STEM and had Latina professionals in STEM join a session as special guests. This session occurred near the end of the GDwCC, so girls were able to talk and reflect with the women about their specific projects. Some of these women created profiles on Flip, which allowed them to view and comment on videos posted by the girls. Because these women participated in some of the sessions and actively commented and interacted with the girls, it made the girls "feel seen and that they were being reviewed by actual persons that live from what they are doing" (Instructor Reflection Notes). Instructors worked to showcase women in STEM and CS in a variety of ways (e.g., with related projects, videos and examples of women in STEM). However, instructors reflected on the challenge of incorporating and showcasing women in STEM noting that these efforts "….kind of felt too much and a little disconnected, not sure if the participants even get to explore the content" (Instructor Reflection Notes).

While many of the activities were engaging and encouraged girls to participate across the duration of the club, there were some missed opportunities where activities could have been improved. While the instructions to explain concepts made some connections to concepts familiar to the girls (e.g., an algorithm is like a set of step-by-step instructions similar to baking or tying a shoelace), more frequent direct connections could be made to their lives that would further demonstrate coding concepts. Similarly, more direct connections could have been made regarding the potential uses of the design ideas and coding content to the girls' lives; instead, most connections were low-level ones.

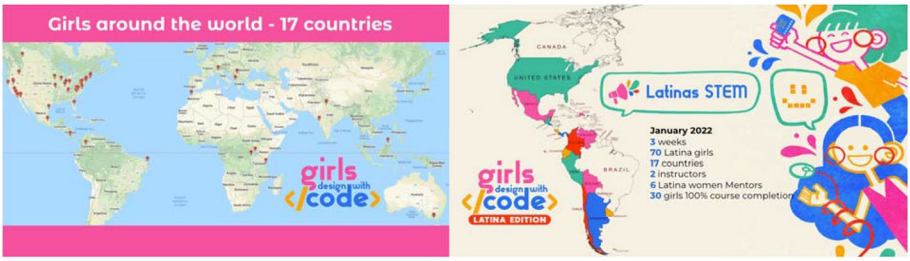

Fig. 2 Visuals showing where GDwCC and Latina GDwCC participants originated from

Cultural background and language

Both the GDwCC and Latina GDwCC forefronted the cultural and language backgrounds of the girls who participated. The instructors intentionally recognized the cultures and backgrounds of the girls, which was especially evident in the Latina GDwCC as it was conducted entirely in Spanish and meant for Spanish-speaking girls. Both GDwCCs highlighted the many countries that were represented by showing a map flagging the countries where participants lived (Fig. 2). The clubs also incorporated the girls' cultural roots and backgrounds in the challenges. This is exemplified by the Week 2 Remix Challenge in the Latina GDwCC, where girls were tasked with using code to create a song that represented their country or themselves.

In addition to recognizing culture and background, the GDwCCs supported girls in their native languages as much as possible. The Latina GDwCC was conducted entirely in Spanish to best support Latinas to learn coding in their native language. The instructors demonstrated their excitement for being able to provide the course in Spanish during the first session, commenting that such opportunities were scarce for Latinas. One instructor commented:

> Hoy estamos súper emocionados porque es la primera vez que va a estar en Español entonces puedes hacer todas este Susane y yo de México. Esto nos emociona mucho... Sabemos que muchas veces es difícil tener acceso a estos cursos y pues bueno lo estamos haciendo con todo nuestro corazón y esperamos que les guste mucho.
> Today we are super excited because it is the first time this program will be offered in Spanish. Since Susane and I are from Mexico, this excites us a lot because we love this audience. We know that it is often difficult to have access to these types of courses, and well, we are doing it with all our heart and we hope you like it a lot. (*Andrea, Instructor in Latina GDwCC; translated from Spanish*)

Additionally, in the second session, while demonstrating MakeCode, the instructor toggled the website language from English to Spanish, which prompted girls to ask how she did that. The instructor then showed the girls how to change the language so that they all could access MakeCode in Spanish (rather than the default language, English). Girls expressed excitement about this option, not having previously realized it was possible. This practice recognized the girls' desire to learn in their native language and also helped to reduce barriers to coding by showing them how to better access the coding platform.

Conducting courses like GDwCC globally poses real challenges related to language (e.g., facilitating separate DwCCs offered in each language). While the GDwCC was

offered globally, the course was presented in English, with instructors also able to quickly translate into Spanish and Albanian. We also had the session videos transcribed to generate subtitles in English and Spanish with the thinking that this might help girls review the videos later or for those who had to participate asynchronously. Most, if not all, participants spoke at least some English, but this is obviously an area where there would be improvement if we were able to have additional languages of instruction. Instructors recognized that all girls were likely not comfortable speaking English, so they encouraged the girls to share their videos in their native language if they preferred to do so:

> We encourage you all to submit projects in English, however, if you are not a native speaker or do not feel comfortable, please share it in your native language (i.e. Spanish, German, American Sign Language or Albanian). (*Email correspondence, GDwCC*)

Instructors also reassured girls that it was okay if they did not speak in perfect English, all working together to make sure each other was understood when asking questions. Instructors reflected on the language barriers after the conclusion of the GDwCC, identifying aspects of language that may hinder participation. First, they noted the importance of being mindful of speaking too fast when presenting in English to non-native English speakers. Second, they perceived that some girls had an expectation of a bilingual experience despite the club being offered in English. Also, since some of the focus was on more technical content (i.e. computer coding) the issues of translation may have been exacerbated for non-native English speakers (Instructor Reflection Notes).

Discussion and Summary

In this analysis we sought to examine the practices used in the Girls Design with Code Clubs that best supported our main goals of getting more girls engaged in learning about design and coding and building community among girls. The GDwCCs were intentionally designed to center problem-solving and design first and coding content second, utilizing problems that tied to participants and their lives. Specifically, the focus was on the problems with coding being the means used to solve them. In the data we noted several practices instructors used that encouraged engagement and participation of the girls and that fostered the development of community. Some of these practices we identified as being positive and some of these spotlighted areas where we could have done better. We identified four categories of practices where the instructors made intentional design choices to improve the likelihood girls would engage with the content: (a) access to materials and information, (b) creating a community, (c) learning that is active and relevant, and (d) recognizing and welcoming cultural background and languages. From this investigation we make the following recommendations to others designing similar experiences, such that each recommendation may address one or more of the categories of practices:

- Be purposeful in curating content (e.g., video, slides) so that participants can review or engage with it outside of synchronous sessions. Part of this process should include considering translation into multiple languages and creating accessible versions of these artifacts.
- Include multiple communication channels for participants to engage with others (e.g., instructors and participants).

- When planning instruction, focus on inclusion of activities that are fun, interactive and tied to the interests of participants, including recognition and celebration of cultural traditions.
- Whenever possible, run sessions in the native language of participants or provide a mechanism for them to get help in that language.
- The content is important, but equally important is the development of a safe, welcoming and supportive environment which is crucial for any learning to occur.

While the GDwCC girls were excited about the prospect of receiving an actual micro:bit, getting the micro:bits to them proved much more difficult than expected. Though we managed to send all the micro:bits to the girls who earned them, shipping them worldwide was not simple. Mailing addresses take different forms and were sometimes hard to confirm, shipping costs varied widely and we often needed to locate local electronics suppliers in different countries. Finally, shipping often came without confirmation so we are not sure if all the micro:bits reached the girls. In the Latina version we were unable to send micro:bits to the participants but were able to send t-shirts as a participation prize. These physical items are exciting incentives to encourage participation and completion of challenges but take a lot of logistical legwork when shipping to so many different nations across the world.

One issue we encountered in all of the clubs was attendance attrition across weeks. While this is common in many educational offerings (e.g., online courses, informal STEM programs, etc.) in a program like this it's still worth figuring out what can be done to retain participants. We think that in our initial DwCC, dropoff was likely based on pandemic online burnout. We saw less drop in attendance from the beginning to the end of the club with the GDwCCs (57% & 67% retention) and believe this is due to the efforts put into developing community among the girls participating. This was done through engaging activities and the 'culture' of caring that was created by the instructors. Although this is often a component that's overlooked, we realize that creating a safe and welcoming learning environment is critical, even in short informal activities, in order to retain participants. This may be particularly critical for young girls in computer science and engineering (Denner, 2011; Rankin & Thomas, 2020).

Since running the two GDwCCs we implemented two other versions—a club for deaf students that included videos interpreted with American Sign Language and a "trainer" version presented to educators in Kosovo. Overall we think that the approach we're using will be particularly useful in getting all kids, but particularly those from groups that are traditionally underrepresented in STEM, interested and engaged in authentic practices. We are not claiming to be doing anything revolutionary. However, we think the rearrangement of focus—(a) centering problem-solving and design, with a secondary focus on content; and (b) using problems that are tied to participants and their lives, seems to be a promising combination. We end with one of the numerous positive comments shared by the girls and their caregivers:

> Me habría gustado que el curso hubiera sido más frecuente,pero eso no afecto mi aprendizaje ni la comunicación entre todas las participantes e invitadas especiales y maestras que estuvieron durante todo el curso. La duración del curso fue excelente porque tuve el tiempo perfecto para conocer a fondo cada tema que se presentaban en cada sesión por que desconocía toda la información que ahí nos impartieron.
> I would have liked the course to be more frequent, but that did not affect my learning or the communication between all the participants and special guests and teach-

ers that were there throughout the course. The duration of the course was excellent because I had the perfect time to get to know in depth each topic that was presented in each session because I was unaware of all the information that was shared with us. (*Mafer, translated from Spanish*)

Acknowledgements We want to acknowledge the participants and instructors of the Girls Design with Code Club Sessions, including Nykema Lindsey, Jona Riznavolli and Claudia Perfecto. This material is based upon work supported by the Infosys Foundation USA and the US National Science Foundation under Grant No. (DRL 2027368). Interested readers can find CoBuild-19 activities and more information at cobuildathome.com. Additionally, those interested in viewing the session can visit YouTube to view Girls Design with Code Club and GDwCC Latina Edition videos here: https://go.iu.edu/4Qh7.

Data availability The primary data that generated the findings of this study are available from the corresponding author, AM, upon reasonable request.

References

An, Y., Kaplan-Rakowski, R., Yang, J., et al. (2021). Examining K-12 teachers' feelings, experiences, and perspectives regarding online teaching during the early stage of the COVID-19 pandemic. *Education Technology Research and Development, 69*, 2589–2613. https://doi.org/10.1007/s11423-021-10008-5

Battal, A., Afacan Adanır, G., & Gülbahar, Y. (2021). Computer science unplugged: A systematic literature review. *Journal of Educational Technology Systems, 50*(1), 24–47.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101.

Buechley, L. (2013, October). Thinking about making. In *Keynote address at FabLearn conference.* Stanford University.

Chakraverty, D. (2022). A cultural impostor? Native American experiences of impostor phenomenon in STEM. *CBE—Life Sciences Education, 21*(1), ar15.

Chang, E. (2019). *Brotopia: Breaking up the boys' club of Silicon Valley*. Penguin.

Corbin, J. M., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative Sociology, 13*(1), 3–21.

Denner, J. (2011). What predicts middle school girls' interest in computing? *International Journal of Gender, Science and Technology, 3*(1), 54–69.

Erol, O., & Çırak, N. S. (2022). The effect of a programming tool scratch on the problem-solving skills of middle school students. *Education and Information Technologies, 27*(3), 4065–4086.

Fee, S. B., & Holland-Minkley, A. M. (2010). Teaching computer science through problems, not solutions. *Computer Science Education, 20*(2), 129–144.

Fessard, G., Wang, P., & Renna, I. (2019, July). Are there differences in learning gains when programming a tangible object or a simulation?. In *Proceedings of the 2019 ACM conference on innovation and technology in computer science education* (pp. 78–84).

Gennari, R., Matera, M., Melonio, A., Rizvi, M., & Roumelioti, E. (2021). Reflection and awareness in the design process: Children ideating, programming and prototyping smart objects. *Multimedia Tools and Applications, 80*(26–27), 34909–34932.

Grant, N. (2022, July 1). Google agrees to pay $118 million to settle pay discrimination case. *The New York Times*. https://www.nytimes.com/2022/06/12/business/google-discrimination-settlement-women.html

Halverson, E. R., & Sheridan, K. (2014). The maker movement in education. *Harvard Educational Review, 84*(4), 495–504.

Irwin, V. (2021, September, 20). Students' internet access before and during the coronavirus pandemic by household socioeconomic status. *National Center for Education Statistics*. https://nces.ed.gov/blogs/nces/post/students-internet-access-before-and-during-the-coronavirus-pandemic-by-household-socioeconomic-status

Kalelioğlu, F. (2015). A new way of teaching programming skills to K-12 students: Code. org. *Computers in Human Behavior, 52*, 200–210.

Kennedy, A. I., Mejía-Rodríguez, A. M., & Strello, A. (2022). Inequality in remote learning quality during COVID-19: Student perspectives and mitigating factors. *Large-Scale Assessments in Education, 10*(1), 29. https://doi.org/10.1186/s40536-022-00143-7

Lapan, J. C., & Smith, K. N. (2023). "No girls on the software team": Internship experiences of women in computer science. *Journal of Career Development, 50*(1), 119–134.
Maltese, A., Paul, K., Simpson, A., & Zych, A. (2022, August). Creating online supports for at home making and STEM projects during COVID-19 (Work in Progress). In *2022 ASEE annual conference & exposition*. https://peer.asee.org/40411
Martin, L., Dixon, C., & Betser, S. (2018). Iterative design toward equity: Youth repertoires of practice in a high school maker space. *Equity & Excellence in Education, 51*(1), 36–47.
Miller, P. H., Slawinski Blessing, J., & Schwartz, S. (2006). Gender differences in high-school students' views about science. *International Journal of Science Education, 28*(4), 363–381.
Muñoz-Najar, A., Gilberto, A., Hasan, A., Cobo, C., Azevedo, J., & Akmal, M. (2021). *Remote learning during COVID-19: Lessons from today, principles for tomorrow*. World Bank Group.
National Center for Science and Engineering Statistics (NCSES). (2023). *Diversity and STEM: Women, minorities, and persons with disabilities 2023*. Special Report NSF 23-315. National Science Foundation. https://ncses.nsf.gov/wmpd
Rankin, Y. A., & Thomas, J. O. (2020, February). The intersectional experiences of Black women in computing. In *Proceedings of the 51st ACM technical symposium on computer science education* (pp. 199–205).
Rich, P. J., Browning, S. F., Perkins, M., Shoop, T., Yoshikawa, E., & Belikov, O. M. (2019). Coding in K-8: International trends in teaching elementary/primary computing. *TechTrends, 63*(3), 311–329.
Rosa, P., Ferretti, F., Pereira, Â. G., Panella, F., & Wanner, M. (2017). Overview of the maker movement in the European Union. *Publications Office of the European Union, Luxembourg*. Retrieved from https://publications.jrc.ec.europa.eu/repository/bitstream/JRC107298/jrc_technical_report_-_overview_maker_movement_in_eu.pdf
Seo, J. (2019). Is the Maker Movement inclusive of anyone? Three accessibility considerations to invite blind makers to the making world. *TechTrends, 63*(5), 514–520.
Strauss, A., & Corbin, J. (1990). *Basics of qualitative research*. Sage publications.
Sung, E., & Kelley, T. R. (2019). Identifying design process patterns: A sequential analysis study of design thinking. *International Journal of Technology and Design Education, 29*, 283–302.
Wilkins-Yel, K. G., Arnold, A., Bekki, J., Natarajan, M., Bernstein, B., & Randall, A. K. (2022). "I can't push off my own Mental Health": Chilly STEM climates, mental health, and STEM persistence among Black, Latina, and White graduate women. *Sex Roles, 86*(3–4), 208–232.
Xavier Hall, C. D., Wood, C. V., Hurtado, M., Moskowitz, D. A., Dyar, C., & Mustanski, B. (2022). Identifying leaks in the STEM recruitment pipeline among sexual and gender minority US secondary students. *PLoS ONE, 17*(6), e0268769. https://doi.org/10.1371/journal.pone.0268769

Adam V. Maltese is a professor of science education and the Martha Lea and Bill Armstrong Chair in Teacher Education at Indiana University—Bloomington. His research focuses on how youth get interested in STEM, with particular focus on the impact of making and inquiry-based experiences.

Kelli M. Paul is an assistant research scientist in the Center for Research on Learning and Technology at Indiana University—Bloomington. Her research focuses on the development of STEM interests, identity, and career aspirations in children and adolescents.

Bárbara Yarza is an Industrial Designer, Artist and Teacher at Universidad Autónoma de Baja California—Mexicali, Baja California, México. Her work focuses on developing creative learning experiences to help people discover, explore and unleash their creative potential, celebrate diversity and increase interest in STEM.

Lauren Penney is a postdoctoral fellow in the Center for Research on Learning and Technology at Indiana University—Bloomington. Her work focuses on supporting communities of learners and STEAM learning environments that inspire young people to create a better world for themselves and their communities.