'Guyanese Girls Code' Goes Virtual: Exploring Instructors' Experiences

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Abstract

The Guyanese Girls Code (GGC) training program, established in 2018, is aimed at increasing female participation in ICT. As a result of the COVID-19 pandemic, the program shifted to virtual operations to ensure the safety of students and instructors. This presented an opportunity to contribute to the growing body of research that has been investigating the virtual implementation of such ICT interventions. Additionally, potential value was recognized in examining the instructors' adoption of the GGC's teaching model to the virtual mode. The program delivered the GGC curriculum primarily via the Scratch programming environment. It involved 80 female students between the ages of nine (9) and fourteen (14), and six (6) instructors. Data was collected via a focus group discussion involving three (3) instructors who shared their experiences of the virtual program. Also, data from the program's student survey was used to gain an understanding of the students' background and to enhance the narrative about the recent iteration of the GGC program. It was found that mentorship and fostering a community of learners were positive extensions of the instructors' role. Further, game-based activities, live demonstrations, breakout rooms and projects were observed to be effective strategies in delivering the program virtually. However, parent-driven enrollment, some aspects of the virtual learning environment and the use of flowcharts for problem solving proved to be challenging. Recommendations were made for future iterations of the GGC program and other similar interventions.

Keywords: Scratch programming, instructor experiences, school children, teaching model, virtual learning environment

1. Introduction

1.1 Support for Guyanese Girls in ICT

The Guyanese Girls Code program is an ICT training program aimed at introducing females from grades seven (7) to nine (9) to the field of ICT, with special emphasis on skills like problem solving and critical thinking. The program stemmed from low enrollment and graduation statistics of females in the Computer Science Department at the University of Guyana (UG), as well as the global underrepresentation of females in the ICT field.

From 2018 to 2020, the then Ministry of Public Telecommunications (MoPT) and the National Center for Educational Resource Development (NCERD) collaborated with UG to implement the GGC program (DPI, 2019). The mission of the program was furthered in 2021 through Guyana's Office of the Prime Minister, Industry and Innovation Unit (IIU). Through the GGC and similar programs, Guyana remains committed to realizing the United Nations (UN) 2030 Agenda for Sustainable Development in the areas of gender equality, reduced inequalities and quality education.

Since 2018, numerous females have benefited from strategic ICT training initiatives in Guyana. To date, approximately 175 female students have completed the GGC program. Many others continue to gain ICT-related skills via national code camps, which aim to further reduce inequalities by targeting students from remote regions of the country (DPI, 2021a; DPI, 2021c). Even during the COVID-19 pandemic, these training projects have persisted. Some were run remotely, while others were conducted face-to-face - adhering to COVID-19 safety measures.

Given that face-to-face programs were conducted at facilities equipped with internet-ready devices, from a resource perspective, they were highly accessible to students. However, due to budgetary constraints and the sudden adoption of virtual delivery at the onset of the pandemic, students opting for the virtual mode were required to have internet-enabled laptops or desktop computers to participate in the program. While the option to enroll in the more accessible face-to-face mode remained, an opportunity was presented to pilot virtual delivery of the GGC program.

1.2 Underrepresentation of Women in ICT

The underrepresentation of women in STEM fields continues to be a global concern for governments and international organizations. Through initiatives such as the 'STEM and Gender Advancement' (SAGA) project and the 'EQUALS Global Partnership for Gender Equality in the Digital Age', governments and policymakers worldwide have been supported in boosting women's visibility, participation and recognition in STEM. Females have been reported to represent only 35% of global enrollment in STEM-related studies at the tertiary level - with notably lower enrollment in disciplines related to ICT (UNESCO, 2017). In 2021, for instance, the European Union reported that only 17% of ICT specialists in its member countries were female (European Commission, 2021); while data from UG revealed that from 2009-2019, the number of female graduates with computing degrees was consistently lower than male graduates (Layne et al., 2020).

These trends are cause for concern because it has been estimated approximately 90% of contemporary jobs are likely to require ICT skills - leaving the possibility of some 1 million unfilled ICT vacancies (UNESCO, 2017). Female underrepresentation in this area is therefore not only damaging to equity, but also presents the risk for current and upcoming shortages and imbalances in the labor market (OECD, 2018). In response, international organizations such as the ITU, UNESCO and EQUALS Global Partnership support and advocate for a concerted effort among governments, the private sector, researchers and other communities in providing a gender-responsive approach to ICT education and representation (ITU, 2021; UNICEF, 2020; OECD, 2018; UNESCO, 2017).

1.3 COVID-19 and Shifting to Virtual Training

The COVID-19 pandemic resulted in a widespread shift to a range of virtual educational strategies (e.g., paper-based take-home packages, television or radio programs, phone calls, tutoring and online platforms) to keep students and teachers safe (Li & Lalani, 2020; UNESCO, 2020). As a result, teachers across the globe swiftly adapted their learning materials and teaching strategies into formats that were suitable for virtual engagement to ensure that their educational efforts and impact persisted. The GGC program also adopted virtual training in an effort to continue safe operations during the COVID-19 pandemic. However, the rapid transition proved challenging because the program's teaching model was tailored to the face-to-face mode of delivery (Layne et al., 2020).

Further, the literature on teaching programming online as of March 2020 was primarily related to higher education settings (McDonald & Dillon, 2021) and massive open online courses, and therefore not readily applicable to the engagement of younger learners in virtual environments (e.g., Skalka et al., 2019; Robinson & Carroll, 2017; Staubitz et al., 2016). While more recent work has emerged to fill this gap (e.g., Benvenuti et al., 2021; Garcia-Ruiz et al., 2021; McDonald & Dillon, 2021), at the height of the COVID-19 pandemic the GGC program encountered a vacuum of knowledge on appropriate techniques and strategies for virtual delivery of programming curricula to younger learners. Nonetheless, the GGC program was successfully completed with 70 out of the 80 students graduating and providing positive feedback.

Considering this successful adoption of a new mode of delivery, we recognize the potential to gain valuable insights from the instructors' experiences. Of interest in particular is how the GGC teaching model - developed to inform the program's curriculum design and teaching strategies in the face-to-face mode (Layne et al., 2020) - was implemented by the instructors for online operations. Insights gained from this study can provide guidance for similar ICT training inventions and inform the extension of the GGC teaching model.

2. Overview

The GGC program's teaching model was originally designed for face-to-face delivery. During the COVID-19 pandemic, it was used in the virtual mode for the first time. In this study, we aim to determine instructors' experiences in adopting the model to this new mode of operations. Our research questions are:

1) How were the components of the teaching model adopted by the GGC instructors?

2) What challenges did the GGC instructors face in adopting the teaching model?

We begin by reviewing the literature on virtual learning engagement and the experience of similar ICT training interventions during the COVID-19 pandemic. The implementation details of the GGC program prior to and during the pandemic are then provided, as well as this study's data collection and analysis techniques. Finally, major findings are discussed.

3. Literature Review

3.1 Fostering Virtual Learning Engagement

Virtual learning engagement typically occurs synchronously or asynchronously. Synchronous methods are delivered live, using communication software with features such as audio, video, text chat, interactive whiteboard, and screen sharing (Lim, 2017; Martin & Parker, 2014). In addition, breakout rooms may be employed for facilitating small group discussions. On the other hand, asynchronous methods are usually facilitated via a learning management platform (UNESCO, 2020; Lim, 2017), which provides mechanisms for students to access learning materials, receive notifications, complete activities and communicate with peers (Lim, 2017). Some training programs are run using either synchronously or asynchronously, whereas others utilize a combination of the two approaches. Regardless of the strategy, four core requirements are needed to facilitate robust virtual learning engagement: high-speed internet service, internet-enabled devices, instructional content, and support such as digital literacy, teacher readiness and technical assistance (Chandra et al., 2020).

There is value in blending the synchronous and asynchronous virtual learning approaches (Yamagata-Lynch, 2014), especially when transitioning from the face-to-face mode (Fadde & Vu, 2014). The synchronous technique mirrors face-to-face classrooms to an extent since it allows live interaction with teachers and peers, but this method becomes difficult to manage when the class size is large (Lim, 2017). Synchronous learning may be coupled with the asynchronous method since learning can be further supported outside of live sessions through access to learning materials, notifications and a network of teachers and peers. However, some major disadvantages of asynchronous learning are delayed feedback, irregular student participation in activities, and notifications or written instructions that are subject to interpretation (Lim, 2017). Nonetheless, students can benefit from the strengths of blending the synchronous and asynchronous learning approaches (Yamagata-Lynch, 2014). In particular, they may be able to better stay on task, gain a sense of stability and develop a stronger connection with peers when engaged in discussions.

Researchers have studied and recommended strategies to improve the virtual learning engagement experience. For instance, Chen et al. (2020) revealed that students had a strong preference for live and pre-recorded lectures alongside synchronous complementary discussions. In addition, engagement activities such as question and answer, small group case study discussions (Chen et al., 2020; Martin & Parker, 2014) and quizzes (Chen et al., 2020; Skylar, 2009) during live sessions were found to encourage engagement. A similar study, involving a larger cross-section of students found that for learner-to-learner engagement, activities such as icebreakers, collaborative work, peer presentations, and peer review of assignments were perceived as valuable (Bolliger & Martin, 2018). Additionally, for learner-to-instructor engagement, regular communication through emails, announcements, reminders, and discussions were deemed important. Furthermore, for learner-to-content engagement, the provision of structured discussions, realistic scenarios, and content in multiple media formats were highly valued. Overall, the least valued activities included synchronous guest talks, events and self-tests.

3.2 ICT Training Interventions

Numerous ICT training interventions for young people have been motivated by low participation within marginalized communities and the slow integration of computing education into the formal school curriculum (Alsheaibi et al., 2020). Supported by universities and/or the public sector, these initiatives are typically conducted as after-school programs and address various social barriers to ICT (e.g., Spartan Girls Who Code (McDonald & Dillon, 2021), Guyanese Girls Code (Layne et al., 2020) and GreekCodersK12 (Misthou et al., 2021)). As a result, they play an important role in making the field more accessible to groups that may be disproportionately affected by limited formal ICT training opportunities (Wang & Moghadam, 2017; Goode, 2008).

Aiming to serve as an entry point to computing and coding, the curricula of these interventions tend to be centered on the fundamentals of computing and computer programming. They commonly use the Scratch programming language, as well as physical computing kits such as the BBC micro:bit, Arduino and Lego

Mindstorms (Alsheaibi et al., 2020). In some programs, the curriculum is also extended to develop students' critical thinking skills and awareness of various social and environmental issues (e.g., Kafai et al., 2021; Misthou et al., 2021). Studies have also focused on the teaching practices and engagement strategies adopted, and the experience and perceptions of the students and/or program instructors in the face-to-face mode (e.g., Alsheaibi et al., 2020; Layne et al., 2020; Aivaloglou & Hermans, 2019; Burke & Kafai, 2010).

However, during the COVID-19 pandemic, researchers began to prioritize the investigation of these initiatives in the virtual mode. For instance, McDonald and Dillon (2021) captured the experience of the Spartan Girls Who Code club as it transitioned to virtual engagement during the pandemic. The club, supported by the students and faculty of Michigan State University, aimed to introduce computing to young female students. In the abrupt transition to virtual engagement, they found technologies and platforms such as Zoom, CodeHS, Google Docs and Remind particularly useful in connecting with students and their parents. Live coding, virtual coding exercises and projects were also key in conducting lessons and assessments. Additionally, in their experience, virtual icebreakers, games, show-and-tell and opportunities for student reflection were also crucial to engagement.

Similarly, Krug et al. (2021) analyzed the results of the 'CodeBeats' camp that was conducted virtually during the pandemic. The intervention leveraged hip-hop, musical coding software and scaffolded exercises to introduce computer programming to minority middle grade students. While this study was not explicitly aimed at distilling lessons learnt from virtual engagement, it is noted that technologies such as Twitch and Mentimeter along with frequent quizzes and creative online classes were used to deliver content and engage the students. These classes adopted the style of a 'news show' through live segments that introduced more detailed pre-recorded sessions.

4. The GGC Program

4.1 The Teaching Model

The GGC program targets females from grades seven (7) to nine (9). It is geared at introducing them to the field of ICT, with special emphasis on 21st century competencies such as problem solving and critical thinking. The 'Motivation, Support and Teaching Components' tree model (MST-tree model) (see Figure 1), developed in the first iteration of the GGC program, informs the curriculum design and teaching strategies used to deliver the ICT training (Layne et al., 2020).

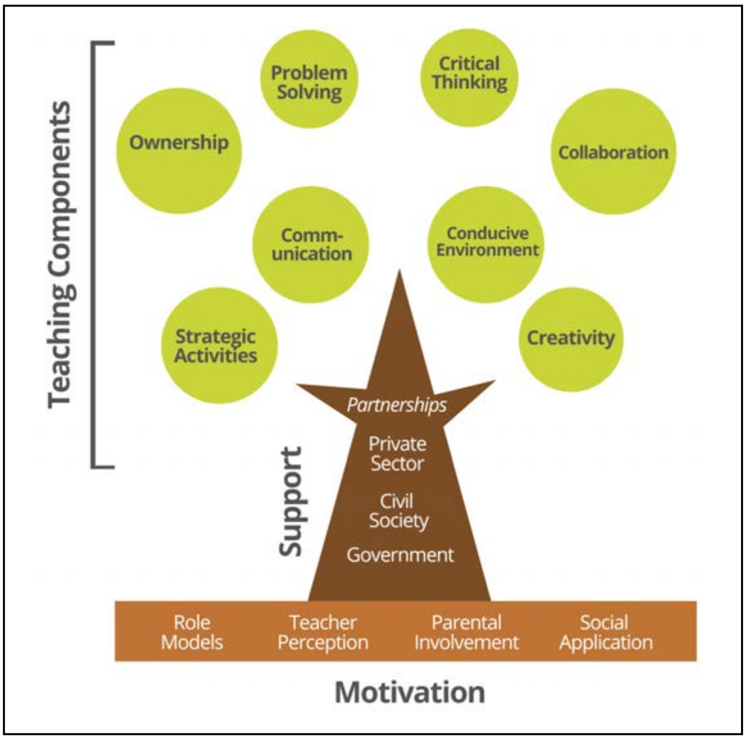

Figure 1. MST-tree model

Taking the form of a tree, the model presents a metaphor for development in the field of ICT. It prioritizes Motivation, Support and Teaching, and outlines elements and strategies within each component. Layne et al. (2020) reported on the positive impact of these components in a previous GGC iteration, thereby lending support to the model's adoption in future programs.

For example, the high levels of self-efficacy and interest generated in the first GGC iteration were attributed to elements within the model's Motivation component. The literature has also more generally identified these elements – inclusive of role models (Stelter et al., 2021; Stoeger et al., 2013), positive teacher perception (Vekiri, 2010), parental involvement (Jungert et al., 2020; Šimunović & Babarović; 2020; Šimunović et al., 2018) and opportunities to explore the social applications of ICT (Vekiri, 2010) – as valuable to children's interest and motivation in ICT.

The Support component of the model was also recognized as a critical enabler for the program. Its role in the overall facilitation of the ICT intervention through the fostering of a conducive environment and ensuring access to training opportunities were notable observations in Layne et al.'s (2020) study of the initial GGC iteration. Furthermore, the Support component's emphasis on partnerships among government, civil society, and the private sector aligns with international advocacy for concerted efforts toward inclusive education and representation.

The Teaching components of the model were proposed because of their potential to effectively deliver ICT curricula and to adequately prepare students for the 21st century. In particular, components such as creativity, problem solving and critical thinking were identified as fundamental skills for promoting active participation in the world of work (Voogt & Roblin, 2012; Trilling & Fadel, 2009). Further, to expose these skills to young people, strategic activities involving tools like Scratch (Oluk & Korkmaz, 2016; Oh et al., 2013) and the BBC micro:bit (Abonyi-Tóth & Pluhár, 2019; Micro:bit Research) were found to be highly effective.

4.2 Transition to Virtual Operations

From the researchers' preliminary investigations of the program, the following subsections detail how the program was designed for virtual delivery:

4.2.1 Implementation and Curriculum

Prior to the COVID-19 pandemic, the GGC program was run as twelve (12) weekly face-to-face sessions. The sessions lasted for four (4) hours each and were conducted between the April to July school period. The program's curriculum comprised three (3) modules (see Table 1), with the first module - Computer Fundamentals and Scratch Programming, focusing on topics such as the fundamentals of hardware and software, female pioneers in computing, ethics in computing, fundamentals of algorithms, problem solving (e.g., narratives, pseudocode), programming fundamentals, the Scratch interface, and code blocks in the major categories (e.g., Events, Looks, Motion, Control, Variables, Operators, Sensing). The BBC micro:bit module, on the other hand, explored the physical features of the micro:bit (e.g., buttons, accelerometer, radio and Bluetooth antenna, processor, temperature sensor), whereas the HTML and CSS module introduced the area of web development. Nine (9) out of the twelve (12) sessions covered the program's curriculum via unplugged (e.g., My Robotic Friends) and plugged activities (e.g., Hour of Code). In addition, two (2) sessions were devoted to creating a Scratch project, and one (1) session was set aside for a written and practical examination.

Table 1. GGC Curriculum modules

Curriculum modules	Duration	Pre-pandemic	During Pandemic
Computer Fundamentals and Scratch Programming	6 weeks	Yes	Yes
BBC micro:bit	2 weeks	Yes	No
HTML and CSS	1 week	Yes	No

During the pandemic, a few changes were made to the GGC's program implementation. For instance, the program was run virtually for eight (8) weekly sessions, between the July to August school break. Each session lasted for three (3) hours, and the students were allowed more breaks (e.g., ten (10) to fifteen (15) minutes after each hour) to reduce virtual meeting fatigue.

In terms of the curriculum, the virtual GGC program focused on the Computer Fundamentals and Scratch Programming module. The BBC micro:bit and the HTML and CSS modules were not included in this iteration of the program, due to the overall reduced delivery time. Moreover, the procurement process to obtain the BBC micro:bits proved to be challenging during the pandemic. Mirroring the face-to-face mode, the Computer Fundamentals and Scratch Programming module was covered in six (6) sessions using plugged and unplugged activities. In addition, the final two (2) sessions were devoted to creating a Scratch project. No written or practical examination was conducted; however, the students received credit for their attendance, homework activities, and the Scratch project. While the project allowed students flexibility to derive their own ideas, specific assessment guidelines were outlined. The students had a choice among the use of algorithms, pseudocode or flowcharts to support problem solving in the final project.

Flowcharting was a new addition to the program. It was taught using digital (i.e., slideshows, Zoom whiteboard) and paper-based methods (i.e., pen/pencil and paper). The slideshow was utilized for presenting an overview of the problem solving approach and was complemented by the Zoom whiteboard for facilitating practical demonstrations and collaborative input from the students. The paper-based approach was employed for individual flowcharting activities, and therefore required photos of the diagrams to be uploaded to Google classroom. The instructors reused algorithms from previous sessions as a problem base for the flowchart demonstrations and activities. These were converted into flowcharts and presented side by side to draw comparisons.

4.2.2 Academic and Government Support

The GGC program curriculum was designed by personnel of the Computer Science Department, UG. During the virtual program, one (1) academic offered weekly guidance to the instructors by reviewing lesson plans and instructional materials, and offering advice on challenges that emerged. Government support took the form of coordinating the student recruitment process, offering technical assistance and Zoom access, providing stipends to instructors, rewarding the students, and ensuring the smooth running of the program.

4.2.3 Program Recruitment

In an effort to spread awareness about the GGC program and the recruitment process, advertisements were published via social media, local newspapers, and government websites (e.g., DPI, 2021b). These advertisements targeted parents and guardians who were responsible for submitting applications on behalf of their children.

Due to budgetary constraints and the sudden adoption of virtual engagement at the onset of the pandemic, students opting for the virtual GGC program were required to have internet-enabled laptops or desktop computers. Nonetheless, working with this group presented the opportunity to pilot virtual delivery, which would serve to inform future iterations of the program.

4.2.4 GGC Recruits and Instructors

Eighty (80) female students between the ages of nine (9) and fourteen (14), were shortlisted for the virtual GGC program. All students were digitally literate and had access to an internet-enabled laptop or desktop computer. The students were assigned to two groups, comprising 40 members each. A preliminary survey was conducted with parental consent to gather information on the students' prior knowledge, expectations, perceptions about ICT, etc.

A total of six (6) female instructors, three (3) per student group, were involved in the GGC program. Each instructor possessed a Bachelor's degree in Computer Science. In addition, several of them served as collaborators on community projects and laboratory demonstrators for introductory programming courses at the Computer Science Department, UG.

With assistance from the Computer Science Department, UG, the instructors collaboratively prepared lesson plans, activities and instructional materials for the program. This strengthened the program's delivery and ensured consistent facilitation across the student groups. During the sessions, the instructors delivered the curriculum, demonstrated practical examples, and offered guidance to the students. They also logged the strengths and weaknesses of each session which were discussed at the weekly planning meetings. To address the challenges faced, the team brainstormed possible solutions and created responsive action plans.

4.2.5 Learning Environment

The virtual program was supported by Zoom, Google Classroom, Gmail and WhatsApp. These platforms were used because a majority of the students and their parents or guardians were already familiar with them.

Zoom was used to facilitate the weekly synchronous engagement sessions, with features such as audio, video, share screen, reactions, chat, whiteboard and breakout rooms being more commonly utilized. Meanwhile, asynchronous engagement occurred via Gmail and Google classroom (e.g., access to instructional materials, assessments, reminders, grade book). As added support, WhatsApp groups were utilized for announcements (e.g., homework and assessment reminders, meeting links, etc.), while direct messages and calls were exchanged between instructors and students (parents and/or guardians in some cases) for the purpose of check-ins and assistance with specific issues (e.g., technical challenges, follow-up questions on topics).

5. Method

Recognizing potential value in examining the implementation of online ICT training interventions, this study aimed to determine the experiences of GGC instructors in adopting the MST-tree model to the virtual mode of operations. This signaled the need for a qualitative study that would allow the researchers to holistically investigate the GGC program and focus on the instructors' subjective perspectives and experiences. Given the key components of the model, the investigation placed emphasis on the instructors' approach to motivating and engaging the students online, the challenges that emerged and the type of support received from the GGC stakeholders.

5.1 Participants

Of the six (6) GGC instructors, three (3) were purposively selected on the basis of their availability and central role in the planning and execution of the program. The instructors (P1, P2, P3) were engaged in a virtual focus group discussion that was centered on examining their experiences across key elements of the GGC teaching model.

Due to the small number of instructors, the researchers opted for one (1) focus group discussion. This approach also provided an opportunity for the instructors to jointly reflect on their individual and collective experiences in facilitating the program, especially since they were attached to different groups.

5.2 Procedure

The focus group discussion was moderated by the researchers who were involved in previous face-to-face iterations of the program. The discussion lasted approximately three (3) hours - with a fifteen (15) minute break in the middle of the discussion. During the discussion, the moderators alternated the roles of note taker and lead moderator. The instructors were encouraged to speak freely and raise additional points. They were also informed that their participation was voluntary and that their responses would remain confidential.

The discussion was guided by semi-structured questions (see Appendix) related to the main components (i.e., Motivation, Support and Teaching) of the GGC teaching model (see Figure 1). These questions were aimed at exploring the instructors' virtual implementation of the components, as well as any challenges encountered. It is recognized that the moderators' past experiences with the face-to-face implementation of the model may have influenced their line of inquiry (see Merriam, 1988), but nonetheless presented an opportunity to further probe the instructors' responses (see Appendix).

Apart from the data that was collected via the instructor focus group, data from the preliminary GGC student survey (e.g., reasons for enrollment, prior knowledge, expectations, etc.), was utilized. The preliminary student survey data served as a supplementary resource to understand the students' background and to enhance the narrative about the recent iteration of the GGC program. Email consent was required from parents or guardians before the students participated in the preliminary survey. A listing of the survey questions was also provided to the parents to increase transparency.

5.3 Data Management and Analysis

The focus group's audio recording was converted to a verbatim textual transcript using an automated audio transcription service. The text was then manually cleaned, and each instructor was assigned a pseudonym.

The researchers then read the transcript multiple times to gain a high-level understanding of the data in its entirety. During this process, both researchers made preliminary notes about the data. In jointly reviewing their notes, it was recognized that substantial units of text in the transcript could be broadly categorized as 'Fact', 'Opinion', 'Recommendation', 'Challenge' and 'Additional Information'. Further, given the study's focus on the adoption of the GGC teaching model by the instructors, the model's primary components guided the creation of the predefined codes for data analysis (i.e., 'Motivation', 'Support' and 'Engagement Strategies'). It was recognized that the data surrounding the Teaching component of the GGC model suggested engagement of the students beyond the teaching context, and thus 'Engagement Strategies' was used as a more appropriate code.

To preserve the context of the coded text and to ensure that both expected and anomalous information could be captured (Creswell & Poth, 2016), the model-derived codes incorporated the preliminary categorizations noted by the researchers. The final coding framework included codes such as motivation-fact, motivation-opinion, motivation-additional-information, motivation-challenge, motivation-recommendation, etc.

The researchers then independently used the framework to undertake qualitative deductive coding. The Dovetail qualitative data analysis software assisted in the process of associating text segments in the transcript with codes from the framework. To allow for verification, the researchers identified and discussed differences between their coding to reach a consensus. The researchers sought to establish at least an 80% agreement (Miles & Huberman, 1994) on codes assigned to text segments. Following this, they mutually agreed on the core ideas and themes emerging from the coded data (see Table 2). The codes related to the Support component were excluded. This is because the supporting agents performed as expected and there was no need for further analysis and discussion.

The emerging themes formed the study's main findings and were analyzed and discussed within the context of the GGC program and data collected from the preliminary survey. Following Creswell and Poth's (2016) recommended validation strategy, the researchers carefully factored the possible impact of their previous face-to-face GGC experience on the interpretation of this study's themes. To further reduce bias and strengthen the dependability of the findings, the researchers also relied on triangulation (Miles & Huberman, 1994; Lincoln & Guba, 1985) to find corroborating evidence and theories from the findings and recommendations of similar studies.

Table 2. Examples of the codes and emerging themes

Text Segment Examples	Codes	Emerging Themes
We not only tried to make the sessions relatable, and our examples practical and relatable, we also tried to make ourselves relatable.	motivation-fact	Mentorship and Learning Communities
And we would encourage them, like in the WhatsApp groups, if someone doesn't understand something, like allow the other girls to help them out instead of us just answering all the questions.	engagement-strategies-fact	
I would say that it was more the parents' idea than the girls. We struggled to sustain that interest.	motivation-challenge	Parental Involvement
I would have to reach out to and message and then I would get a response.	motivation-fact	
We need to get the parents more involved.	motivation-recommendation	

We used the Tower of Hanoi, which the girls solved like really quickly and they went above and beyond with that one.	engagement-strategies-fact	Effectiveness of Games
…at first we thought it [flowcharts] would have been simple, but it turned out to be extremely complex for the kids	engagement-strategies-challenge	Flowchart Challenges
...the implementation [final project] in Scratch did not reflect the problem. A few of them... were implementing projects that they didn't even [propose]	engagement-strategies-challenge	Final Scratch Project
...rather than telling them what to do, we literally demoed it... you have to do this like this, click that, you know... to help them overcome these hurdles.	engagement-strategies-fact	Virtual Engagement
...we say, just a second OK, we're coming to you... in a way to encourage them and keep that momentum going.	engagement-strategies-fact	Virtual Learning Environment Constraints

6. Discussion of Findings

This section discusses the findings on how the GGC teaching model (see Figure 1) was adopted by instructors in the virtual mode of operations. Of interest within the 'Motivation' component were mentorship and learning communities, as well as parental involvement. Furthermore, areas that stood out for the 'Teaching' component of the model included game-based activities, challenges surrounding flowcharts, effective virtual engagement strategies, Scratch-related assessments and constraints of the virtual learning environment.

6.1 Mentorship and Learning Communities

Data collected from the GGC instructors suggest that motivation was fostered through the presentation of relatable role models to the students. It was found that instead of primarily relating stories of local and international women in ICT for this purpose (Layne et al., 2020), the instructors more readily emphasized their personal experiences as professionals in the field.

> *We not only tried to make the sessions relatable, and our examples practical and relatable, we also tried to make ourselves relatable. (P1)*

The instructors' gravitation towards relatability signals a proactive attempt at extending their facilitation role to include role modeling and mentorship. There is considerable value in this since mentorships within STEM-focused activities have the potential to enhance students' science identity, self-efficacy, interest and commitment to pursuing related careers (Stelter et al. 2021; Stoeger et al., 2013). Further, in building the rapport required for the mentoring relationship by, for example, engaging in casual conversation (McReynolds et al., 2020) during breaks and after classes, the instructors may have been able to bridge their distance within the virtual environment and better position themselves to motivate the students.

> *Simple things like asking them about their day or what they're doing, like when we have breaks... they feel more comfortable and have better interaction. (P3)*

Additionally, the instructors' approach to 'mentoring' aligned with the effective many-to-many group mentoring structure (Stoeger et al., 2017) whereby students benefited from access to two or more instructors identified as mentors. Further, the instructors were observed to have encouraged learner-to-learner engagement not only inside, but also outside of the program's virtual classroom environment.

> *And we would encourage them, like in the WhatsApp groups, if someone doesn't understand something, like allow the other girls to help them out instead of us just answering all the questions. (P3)*

Collectively, these developments may have implications on extending the GGC teaching model to include the fostering of a learning community that provides the "structure for social interactions among students, their peers and STEM professionals" (Misthou, 2021, p. 956). Such an extension should also consider the training of prospective mentors to effectively create and sustain mentoring relationships (Stelter et al., 2021).

6.2 Parental Involvement

With respect to parental involvement as a source of motivation for the GGC students, the instructors observed that enrollment in the program may have been strongly influenced by the students' parents and guardians. This was corroborated by the program's initial survey data:

> *Honestly, my mom put me in this course and she didn't really give me an option, at first I thought it was a burden but then I told myself why not give it a shot. Also, this may be a benefit to my future so I accepted it. (GGC Student)*

While it has been found that parents' positive perceptions, enthusiasm and communication of STEM-related values are important in stimulating children's motivation in STEM (Šimunović et al., 2018; Jungert et al., 2020), the instructors viewed their experience of this in the form of parent-driven enrollment as a possible cause for later challenges in sustaining the students' engagement and motivation.

> *I would say that it was more the parents' idea than the girls. We struggled to sustain that interest. (P2)*

This suggests that the dynamics of parental involvement in fostering children's motivation and interest should be carefully considered. As highlighted by Šimunović and Babarović (2020, p. 712), "parenting style, parents' support for a child's autonomy, and communication patterns... during coactivity" should be factored alongside parents' involvement in their children's educational and leisure activities in STEM-related fields. Therefore, as pointed out by the GGC instructors, parent-driven enrollment may have affected some students' autonomy in the program, which then reduced their sense of capability, interest and engagement. Further, primarily relying on parental involvement for fostering program awareness and enrollment may have excluded females whose parents are not aware of or interested in the field of ICT.

Collectively, these observations suggest the need to consider revision of the GGC program's recruitment strategies given that the current approach makes use of advertisements primarily targeted at parents (e.g., DPI, 2021b). It may be worth exploring additional recruitment strategies that are more inclusive and tailored to directly inviting females into STEM classrooms (e.g., outreach material featuring relatable female role models, Girls in STEM events or career fairs, conferences and collaboration with school counselors) (Shadding et al., 2016; Milgram, 2011).

6.3 Effectiveness of Games

The instructors used real-world scenarios, analogies and games to foster engagement. However, they observed that game-based activities generated the most interest among the students. This finding is similar to the study by Malliarakis et al. (2014), which reported that the use of games for teaching programming can provide a range of engaging characteristics (e.g., storytelling, scaffolding, interactivity), which positively impact student participation and encourage the completion of tasks through interesting scenarios.

During the earlier sessions, games were used to break the ice (e.g., The Fortune Teller [3]), encourage problem solving (e.g., TED-Ed Riddles[4], Tower of Hanoi[5]) and reinforce concepts in the GGC program.

> *...rather than just explaining what problem solving is - the concept, we used the Tower of Hanoi, which the girls solved like really quickly and they went above and beyond with that one. (P1)*

Motivated by the enormous interest in game-based activities and students' preference for the creative elements of the Scratch environment (e.g., animating characters and creating personalized worlds) (Kalelioglu & Gülbahar, 2014), the instructors designed the later Scratch activities to allow students to create their own games.

> *I think the visual aspect of it [creating games using Scratch] was fun because it wasn't just programming with blocks. It was also the fact that they could see... their end goal while they're coding with blocks. It's really motivational. (P1)*

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[3] A turn-taking game, played in groups, for predicting the future of computing technology
[4] https://www.youtube.com/watch?v=7yDmGnA8Hw0
[5] https://www.mathsisfun.com/games/towerofhanoi.html

Impressively, the students made excellent Scratch submissions well in advance of deadlines, confirming the instructors' observations about high levels of interest in game-based activities.

6.4 Flowchart Challenges

The instructors reported that the use of flowcharts as a problem solving tool was the most challenging topic in the program. Unlike Scratch, it was observed that a significant number of the flowchart-related submissions were not timely and/or inaccurately portrayed solutions to problems:

> *...at first we thought it [flowcharts] would have been simple, but it turned out to be extremely complex for the kids. (P1)*

While it is acknowledged that game-based activities were not utilized in this part of the program, additional support was provided through breakout room activities, after-class remediation and peer support; however, the issue persisted. Similar studies have observed this waning interest in flowchart-related activities (Erol & Kurt, 2017) and potential complexity of the topic for younger students (Ali & Saltan, 2015). While further investigation into the student perspective is needed, it may be reasoned that the shift from game-based activities to flowcharts may have also reduced student interest and motivation in the topic area.

The use of flowcharts during Scratch activities may have contributed to further challenges. For instance, while Scratch code blocks such as 'repeat until' hide an iteration's conditional check, the decision component of the flowchart requires it to be explicitly captured. Disconnects of this nature may have limited the students' ability to translate flowchart components to the programming concepts learnt in Scratch. Future research may therefore find it worthwhile to investigate the extent to which flowcharts serve as a compatible problem solving tool for Scratch.

6.5 Final Scratch Project

It is noted that students were able to exercise 'ownership', a strategic component of the program's teaching model (see Figure 1), in the final assessment. Through individual Scratch projects, they were tasked with proposing their own ideas which they were then expected to design and implement. The instructors largely considered this strategy to be effective since a significant number of students successfully completed the activity, with algorithms and pseudocode being popular choices for problem solving. However, the instructors also highlighted a few instances whereby the students implemented projects that differed from their proposed ideas:

> *...the implementation [final project] in Scratch did not reflect the problem. A few of them... were implementing projects that they didn't even [propose]. (P1)*

While there is a need to investigate this further from the students' perspective, it signaled issues with their willingness to persist with problem solving and seeing a project to its completion. Future virtual iterations of the program may therefore find value in utilizing scaffolded projects via milestones (e.g., Krug et al., 2021). Furthermore, similar studies have found collaborative work to be a strength, due to the positive motivational impact and support that students can provide to each other (Sentance & Csizmadia, 2017).

6.6 Virtual Engagement

Some engagement strategies that were found to be effective in the virtual setting were breakout room activities, live demonstrations of coding, and collaborative debugging and troubleshooting.

Breakout rooms, not greater than ten (10) students, were observed to boost learner-to-instructor and learner-to-learner engagement. For example, when problem solving was taught, the students and instructors were placed into breakout rooms to engage in discussions, collaborate and showcase different ways of solving the same problems. Remarkably, students who contributed less frequently in larger group sessions were more outspoken in the breakout rooms.

Live coding demonstrations also promoted learner-to-instructor engagement and were especially effective for exhibiting samples of model programs. This helped students to better understand what was expected. Screen sharing by students also fostered learner-to-learner and learner-to-instructor engagement by allowing the class to collaboratively debug programs and troubleshoot the Scratch environment.

> *...rather than telling them what to do, we literally demoed it... you have to do this like this, click that, you know... to help them overcome these hurdles. (P2)*

6.7 Virtual Learning Environment Constraints

Constraints observed in the virtual learning environment included issues with communication via Zoom and limited opportunities for social applications of ICT.

The instructors revealed that managing communication during Zoom sessions while simultaneously teaching and sharing their screens was challenging. For instance, if several students interacted via the Zoom chat feature, the instructors would find it difficult to maintain a high level of responsiveness while conducting the lesson. As such, it was recommended that future iterations place more emphasis on verbal communication via Zoom and designate an instructor to monitor the chat.

While session rules such as ‘raise hand’ and ‘wait your turn’ were initially put in place to enforce order and efficient communication, the instructors observed that it did not create a comfortable environment for the students, thus:

> *...we say, just a second OK, we’re coming to you... in a way to encourage them and keep that momentum going. (P2)*

As a further constraint, in the virtual mode, the range of ways in which social applications of ICT could have been demonstrated was limited. Unlike previous face-to-face iterations of the GGC program, which provided students with first-hand exposure to the field and a real-world appreciation for its application, the virtual mode relied heavily on analogies and explanations for this purpose. As such, future iterations may explore the inclusion of ICT webinars, virtual STEM fairs, virtual reality tours, and live streams.

7. Conclusion

In this study, we explored the adoption of the GGC program’s teaching model to the virtual mode of operations. We found that the instructors proactively extended their teaching role to include mentorship. They also encouraged informal learner-to-learner interaction. Notably, these developments are capable of contributing to the creation of a virtual learning community. In addition to this, it was found that Scratch and game-based activities, live demonstrations, breakout rooms and projects that fostered ownership were effective in delivering the program virtually, as opposed to Zoom chat and session rules.

It was also noted that other constraints of the virtual mode, compounded by the COVID-19 pandemic, limited the range of ways in which the social applications of ICT could have been demonstrated. It is therefore recommended that future virtual programs explore alternative techniques.

In addition, parent-driven enrollment may have been a possible cause for challenges in sustaining engagement and motivation. This suggests that there is a need for closer examination of the dynamics of parental involvement, as well as a review of the program’s recruitment strategies.

Furthermore, the use of flowcharts for problem solving was observed to be particularly challenging for the students. While we have found studies reporting waning interest and potential complexity with flowchart-related activities, there appears to be limited research on the extent to which flowcharts serve as a compatible problem solving tool in programs of this nature.

Overall, we recognize that these findings can guide the extension of the GGC program’s teaching model, as well as the design and implementation of other ICT training interventions.

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Appendix A

Key components that guided the creation of the focus group questions

The focus group discussion was guided by semi-structured questions related to the following components of the GGC teaching model (see Section 4.1):

- Motivational Components - Reflection on sources of motivation for the students (e.g., parental involvement, instructor perception, female role models, social applications, etc.).
- Supporting Components - Investigation of the supporting systems and resources that were made available to the instructors.
- Engagement and Teaching Strategies - Reflection on the strategic engagement activities that were employed and how they may have facilitated a conducive learning environment for the students (e.g., opportunities to collaborate, communicate and exercise critical thinking and problem solving skills).
- Challenges - Reflection on specific challenges faced by instructors and students during the programme (e.g., challenging topics, remedial steps, etc.).

Table A1. Focus group questions related to Motivation

MST-tree Model Component	Focus Group Questions

Motivation Components:
parents, teachers' perception, female role models, social applications
	• What practices (strategies, techniques) were employed (if any) to motivate and inspire the students?
	  o Probing mentor relatability as a motivation strategy:
	    ▪ What techniques did you use to make the girls see you as relatable?
	• To what extent were parents/guardians involved in the GGC program?
	  o Probing the influence of parents'/guardians' involvement on student enrolment and interest
	    ▪ Do you think the parents were more interested in the program than the girls?
	• To what extent did mentors' perception (open opinions, judgements, thoughts, recognition) play a role (e.g. communicating confidence in the students' ability) in the GGC program?
	• To what extent were female role models (e.g. women in ICT - Guyana/Internationally) involved/included in the GGC program? How?
	• To what extent did social applications of ICT (e.g. videos or discussions about real world ICT interventions, field trips, games) play a role in the GGC program?

Table A2. Focus group questions related to Support

MST-tree Model Component	Focus Group Questions
Supporting Components: OPM, Training, UG	• To what extent did OPM play a significant role (e.g. finances, Zoom license, recording videos, Zoom technical support) in supporting the GGC program? • To what extent did the UG (CS Department staff) support (e.g. previous learning materials, curriculum, weekly meetings and guidance) the GGC program? • To what extent did previous training/experiences (e.g. BSc degree program, club involvement, MoPT, STEM Guyana, running UG tutorials) prepare you for the GGC program? • What resources (e.g. Zoom, internet, Google classroom) were made available to you (or utilized) to deliver the program online? • How reliable was internet access for you? • What type of device(s) did you use to conduct the program? • How conducive (comfortable, noise-free, cool, professional) to teaching was the environment in which you conducted the program?

Table A3. Focus group questions related to Engagement

MST-tree Model Component	Focus Group Questions

Engagement/Teaching Components: Strategic Activities, Conducive environment, Problem solving, Critical thinking, Collaboration, Communication, Creativity, Ownership	• What engagement strategies did the students respond more positively towards?
	• What engagement strategy or strategies were least effective?
	• Did you employ strategic activities (e.g. think-pair-share, plugged, unplugged, whole group, breakout rooms) to explain particular programming concepts? If yes, please provide a few examples.
	  o Probing specific engagement strategies:
	    ▪ How were breakout rooms used?
	    ▪ How were games used?
	    ▪ Do you think that the strategic activities had an impact on learning programming concepts?
	• In what ways did you strive to make the online space a conducive environment (e.g. comfortable, psychologically safe space) for learning?
	• Did any challenge (e.g. issues completing and/or submitting home-work activities, quiet review of concepts not making sense) result in further interactions outside of the weekly sessions?
	• Were the students afforded opportunities to collaborate with each other? If yes, please provide a few examples.
	  o Probing learner-to-learner collaboration (out of class)
	    ▪ How was the communication group initiated and used?
	• Were the students afforded opportunities to exercise and/or develop their communication skills? If yes, please provide a few examples.
	• Were the students afforded opportunities to exercise and/or develop their creative, problem solving, critical thinking skills? If yes, please provide a few examples.
	  o Probing the strategies used for problem solving
	    ▪ Given the challenges with flowcharts, how did the students complete problem solving activities?

	- Were the students afforded opportunities to exercise and/or develop a sense of ownership (e.g., freedom to create and share individual ideas)? If yes, please provide a few examples. o Probing opportunities for ownership ▪ How would you compare activities that encourage creativity and ownership against those that are more structured?

Table A4. Focus group questions related to Challenges

MST-tree Model (Overview)	Focus Group Questions
Challenges	- What difficulties, if any, have you experienced teaching programming (e.g. of barriers - explaining concepts, teaching or visual aids) in the online mode? - What topics in the GGC curriculum were most challenging for the students? Why? o Probing challenges with flowcharting ▪ Why do you think flowcharting was so problematic for the students? - Do you think the virtual mode made it harder to problem solve with flowcharts? - What topics in the GGC curriculum were most challenging (e.g. time and effort to prepare, uncertainty, a struggle to engage the class) to teach? Why? - Were remedial steps (e.g. teaching concepts using a different method to improve understanding) taken to help students to understand topics that they found more challenging? If yes, please provide details regarding the remedial steps that were taken and what was the outcome.