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Technovation 2018 Evaluation Final Report

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Introduction

Technovation is a global technology entrepreneurship competition for girls organized by Iridescent. Teams of girls spend approximately twelve weeks addressing a problem in their community through the creation of a mobile app and business plan. Like other Iridescent programs, the goal of Technovation is to "develop and instill a greater understanding of the engineering design process, a mindset of curiosity, creativity and persistence." More than a competition, Technovation is also a community of alumnae, mentors, student ambassadors, regional ambassadors, and other supporters who encourage youth to explore and pursue STEM. Since its launch in 2010, the program has reached over 23,000 girls.

Prior evaluations of Technovation have demonstrated the successful impact of this program, for both girls and their mentors. Girls increase their interest in computer science, entrepreneurship, and business. Mentors increase their own knowledge in these areas and continue to develop their mentoring skills. With a goal of continued expansion and participant retention, Iridescent expressed an interest in understanding why certain participants do not complete the challenge or decide to return in subsequent years. Iridescent contracted WestEd to evaluate Technovation 2018 with a focus on three areas: (a) college and career readiness, (b) computer science academic achievement, and (c) mentor training.

WestEd conducted a formative evaluation of Technovation 2018, which primarily serves to identify a program's strengths and weaknesses and to provide feedback that can lead to improvements. We employed a mixed-method approach drawing from both qualitative and quantitative data gathered through surveys, observations, focus groups, interviews, reflection cards, and reviews of Technovation courses and girls' App Inventor projects. Quantitative data were analyzed using descriptive statistics, chi-squared tests, and t-tests. This analysis allowed us to summarize participant responses and make claims about the significance of trends in their responses. Qualitative data were analyzed using an open coding approach, allowing us to identify common themes in the ideas participants shared with us. Both quantitative and qualitative data were considered together to present a cohesive picture of participants' experiences during the 2018 season. In reviewing this evaluation, the reader should consider the following:

- Participants completed surveys at the beginning and end of the 2018 season. However, it was not possible to match individual responses across the two surveys. Any pre-to-post comparisons mentioned in this evaluation describe differences in the group of pre-season respondents and the group of post-season respondents.
- Some sections of this report focus on the following country groups: 1) the United States; 2) Spain; 3) Canada, Mexico, Brazil, India; and 4) all other countries. These country groups were selected based on mentor registration data as of March 2018. The U.S. had over 500 mentors. Spain had over 400 mentors. Each country in group 3 had over 200 mentors. Each country in group 4 had 143 or fewer mentors.

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- Due to the large number of survey collected ($n_{student}$ = 3,941; n_{mentor} = 1,846), we narrowed the qualitative analysis of open-ended survey items to a subsample of respondents. For the student surveys, 560 surveys were selected from each administration. For the mentor surveys, approximately 130 surveys were selected from each administration.

The results of this evaluation are presented in two documents. The *Final Report*, this document, focuses on presenting the main findings of the evaluation. It is divided into three sections: findings about students, findings about mentors, and recommendations for future seasons. The *Methods Supplement* provides more detail on our data collection and analytic approach. It also describes the research informing our evaluation.

Summary of Findings

Technovation continues to provide a challenging and impactful experience for girls and mentors. Similar to past years, girls participating in the 2018 season increased their confidence and their desire to pursue computer science (CS) and business in the future. Mentors and family members were critical to this experience, providing girls with the motivation to persist. Some girls faced barriers in the season including difficulty with the curriculum, diminished motivation, limited Internet and computer access, and balancing other commitments. Potential areas of improvement for future seasons include: (a) explicitly focusing on college and career readiness; (b) developing ways to identify and incentive girls who have become demotivated; and (c) revising the curriculum to include more supports around programming and to be more accessible, especially for junior division participants.

Evaluation data highlighted the varying skills, motivations, and beliefs mentors bring into their Technovation experiences. Their specific needs vary based on the number of teams they mentor, whether they participate in-person or virtually, and if they are new or returning mentors. With such diversity, there is no universal solution to supporting all mentors. While some mentors praised existing Technovation supports, others were unaware that they existed. Developing a system (e.g., discovery engine) that points mentors to the supports they want and need can be beneficial. Other potential areas of improvement include: (a) reorganizing Slack channels to help mentors find topics of interest and (b) including a greater focus on programming and business topics either in mentor courses or fused into the student curriculum.

> *"We had a mesmerizing experience working on Technovation. Technovation is an amazing platform and we would like to thank this organisation for providing us such a wonderful opportunity which made us feel proud."*
>
> — Junior Division Participant from India

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1. Findings about Students

Data are drawn from student surveys collected at the beginning and end of the 2018 season, interviews, and observations. Student survey data could not be matched between the pre-season and post-season administrations, so we do not report on changes in individuals. Instead, the survey comparisons presented here reflect differences between the group of students who completed the pre-season survey and the group of students who completed the post-season survey. While these two groups have a similar distribution of student age and country, there may be systematic differences between participants who completed the post-survey and those who did not that influence the evaluation results.

Students increase their confidence in particular skills and their self-confidence.

Survey responses show statistically significant increases in student confidence across multiple skills related to coding, business, and problem solving (see Figure 1.1). The greatest increases in confidence are related to App Inventor programming and building and managing a business.

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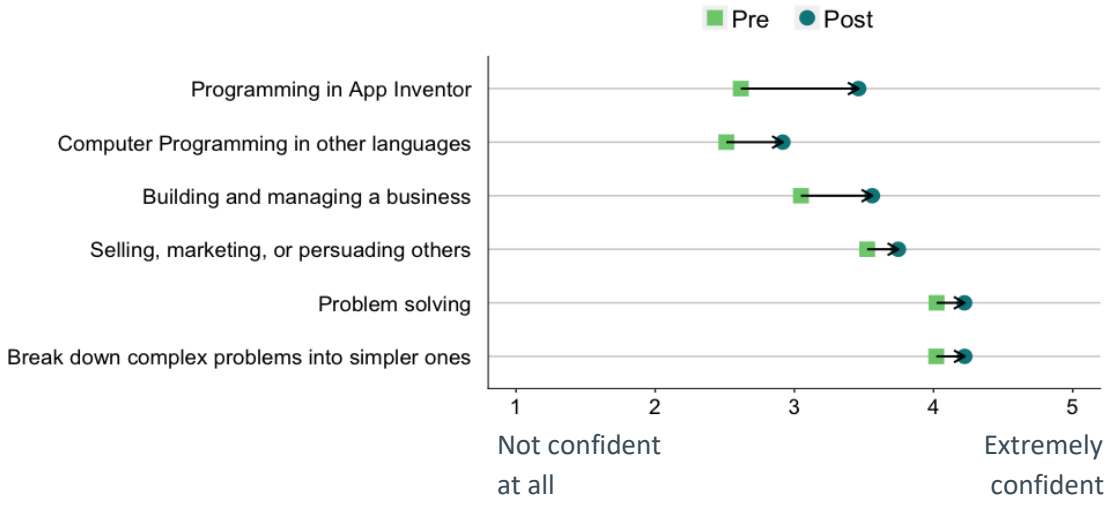
FIGURE 1.1

How confident are you in the following areas?



We also observed an increase in self-confidence during visits with Technovation teams. In a January 2018 focus group with participants in Cameroon, we met with three girls who participated in the 2017 season and four girls participating in the 2018 season. The 2017 cohort presented themselves boldly, shared many ideas about Technovation, and discussed their future educational plans. In contrast, the 2018 cohort offered fewer comments and appeared hesitant to ask questions.

In April 2017, while attending a Technovation *Ask the Expert Event* in Silicon Valley, we observed a student meeting with two marketing experts. The student asked a few questions about how to prepare a video for her pitch but remained silent for most of the conversation. A month later at the *South Bay Junior Division Event*, we talked with the same student during the App Expo where she discussed how public speaking made her nervous. However, later that evening, the student took a lead role in presenting her group project confidently and clearly during the pitch competition.

Students finish Technovation wanting to pursue more courses, training, and careers in CS and business.

Students begin Technovation valuing CS and business. When asked on the pre-survey if coding or business were important to their career objectives, most students responded yes, and responses remained similar on the post-survey. At the end of the season, we noticed an increase in the percentage of students who indicated that they plan to pursue one or more fields related to CS or business when they go to college. Interest in CS-related studies appears greater than interest in business-related studies.

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FIGURE 1.2

Girls' interest in coding and business for future study and careers

Knowing how to code is important in meeting my career objectives.		
	Pre-season	Post-season
Yes	60%	57%
Maybe	35%	37%
No	5%	7%

Knowing how to run a business is important in meeting my career objectives.		
	Pre-season	Post-season
Yes	71%	66%
Maybe	27%	31%
No	2%	3%

List up to three fields you might study in college.		
	Pre-season	Post-season
1 or more CS fields listed	47%	56%
1 or more business fields listed	15%	20%

These survey findings mirror the results of a focus group we conducted with student ambassadors in May 2018. For example, some students said they planned to pursue CS in college before starting Technovation, so their Technovation experiences did not influence their college or career plans. Other students, however, discussed how their Technovation experience shifted the focus of their future plans, sometimes opening their eyes to fields they had not considered. As one student told us:

> *For me Technovation really affected what I want to do in college. . . I had some experience before with programming in general, but Technovation really showed me the business and entrepreneurship side as well. . . and I really like that part of it, so now I have a better idea of maybe in college, I want to do like business or as a career I want to combine business and software programming. So yeah- I'm really grateful to Technovation for that.*

Similarly, evidence of the long-term impact of participation in Technovation was also mentioned during a focus group with participants in Yaoundé, Cameroon. Girls who participated in the 2017 Technovation season, but who are not currently involved due to their national exams, discussed plans to learn HTML on their own. A regional ambassador shared a story of a former participant who is now studying computer engineering in college.

Although this type of change was observed both in interview and survey data, it appears that Technovation has an opportunity to further magnify this impact. For example, some mentors we interviewed told us they had not discussed college plans or career aspirations with their participants. Nevertheless, they all stated including this topic in the Technovation curriculum could prompt mentors to have purposeful discussions with their students about thoughts and plans for the future.

In their survey responses, Regional Ambassadors (RAs) also provided suggestions on how Technovation could better support its participants to prepare for college in the future. Their suggestions included:

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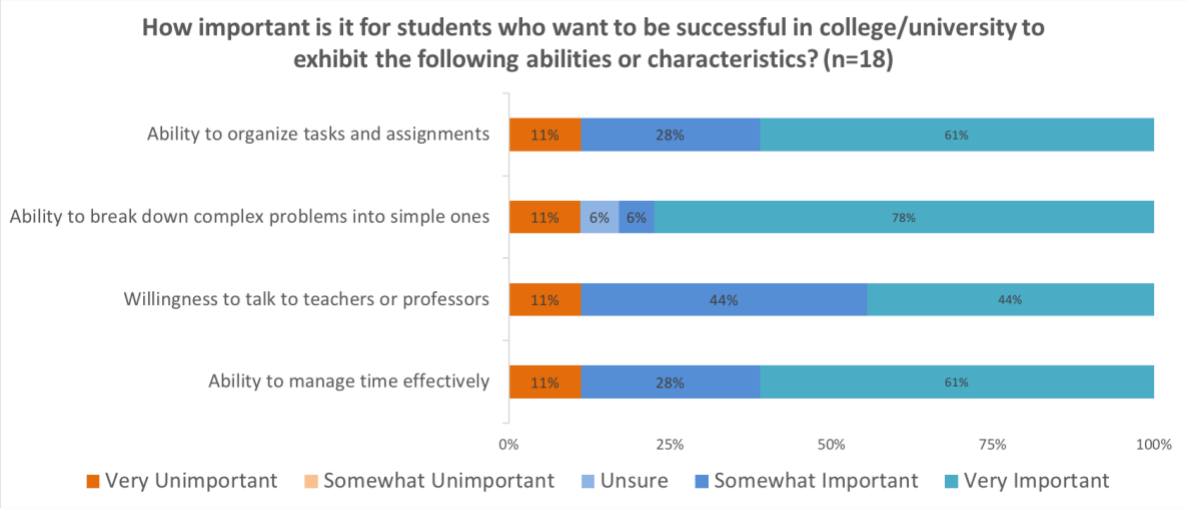
- Incorporating information in the Technovation curriculum about different professions related to computer science, business, or engineering, and including a list of subjects that would be needed to prepare for these fields.
- Partnering or connecting teams with college alumni or professional women who work in these areas, who can serve as role models for the girls and demonstrate what is possible for them to achieve.
- Conducting outreach to both parents and participants to educate them about different career options that are available in STEM.

Influencing students' college and career readiness requires a more explicit focus.

Part of our scope of work included an examination of how Technovation may impact participants' college readiness. We chose to narrow our focus to college readiness areas that were most likely to be impacted by participation in Technovation, including time management and planning skills, communicating with adults, problem solving, and academic self-efficacy. Respondents largely indicated that these behaviors were either somewhat or very important for students to be successful in college. More than 88% of Regional Ambassadors stated that it was important for students to be able to organize tasks and assignments, manage their time effectively, and talk to teachers; 84% also stated that it was important for students to be able to break down complex problems into simple ones.

FIGURE 1.3

Regional Ambassadors perceptions of college and career readiness characteristics



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An examination of the pre-survey responses revealed that girls entered the season with a high degree of academic self-efficacy and confidence in the types of cognitive strategies and academic behaviors identified as important to college success. As a result, there was little room for growth on the post-survey. Post-survey mean scores were roughly equivalent with pre-survey mean scores on all college-readiness related items (see Table 1.1).

TABLE 1.1

Girls' confidence and ability in college and career readiness areas

College and Career Readiness Area	Survey Item	μ_{pre}	μ_{post}
Key Cognitive Strategies	Participants rated their confidence in their ability to break down complex problems into simpler ones on a five-point Likert scale (1= not confident at all; 5= very confident).	4.00	4.28
Academic Self-Efficacy	Participants rated their overall academic ability as compared to the average student on a five-point Likert scale (1= very poor; 5=excellent).	4.28	4.35
Academic Behaviors	Participants rated their confidence in their ability to manage their time effectively on a five-point Likert scale (1= not confident at all; 5= very confident).	3.95	4.07
	Participants rated their confidence in their ability talk to their teachers on a five-point Likert scale (1= not confident at all; 5= very confident).	4.36	4.39

Furthermore, participants were asked to identify the frequency with which they engaged in specific time management strategies on a four-point Likert scale (1 = rarely; 4 = always), such as setting deadlines for themselves, keeping a list of the things they need to do each day, and having a clear idea of what they would like to accomplish in the week ahead. Participants' scores on the pre-season and post-season surveys showed similar patterns, with girls reporting an average score of "often" in their use of setting deadlines (μ_{pre} = 2.92, μ_{post} = 3.06), the frequency with which they keep a list of the things they need to do (μ_{pre} = 2.83, μ_{post} = 2.86), and the frequency with which they had a clear idea of what they wanted to accomplish in the next week (μ_{pre} = 2.91, μ_{post} = 3.03).

We asked girls to describe the strategies they use to manage their time or organize their work in order to gain more insight into the number and type of planning skills they employed before and after the season. In a similar pattern to the Likert scale items described above, we were unable to find any differences between the pre-season respondents and the post-season respondents. Students' use of these strategies largely remained unchanged (see Figure 1.4).

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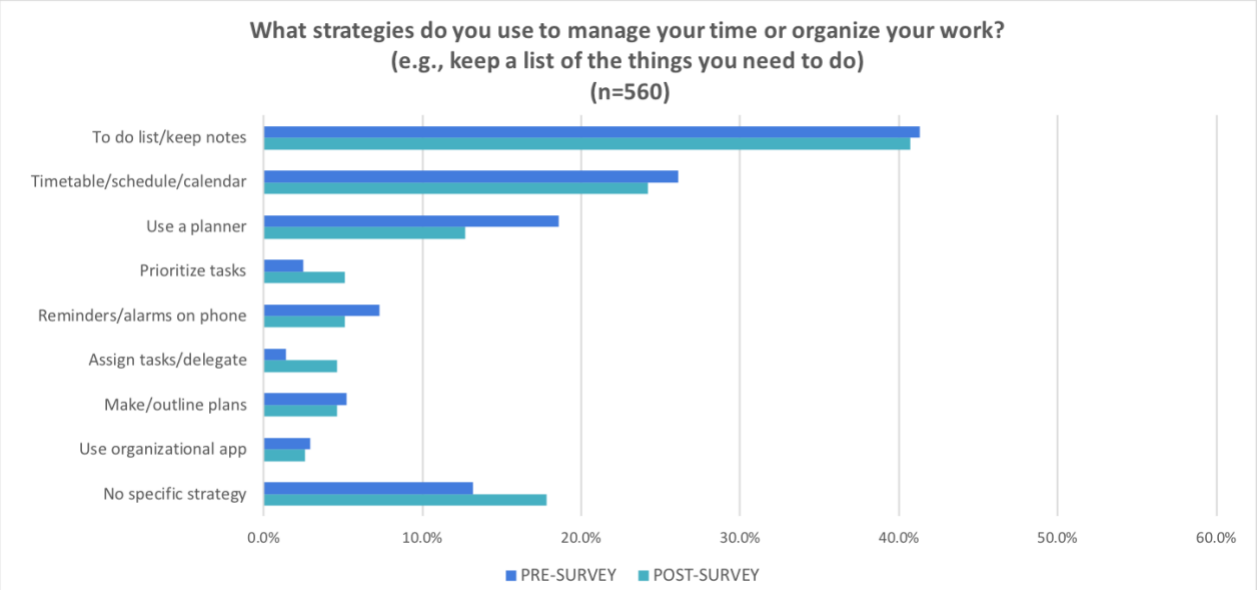
FIGURE 1.4

Students' time management strategies



We asked some mentors about girls' use of time management strategies. Mentors cited similar strategies to those identified by students but said that these strategies were frequently initiated or led by the mentor. Time management and organization was often cited as a challenge by mentors and students alike during interviews and focus groups. Consequently, this appears to be another area in which Technovation might further develop its curriculum to provide more explicit guidance to participants on the importance and worth of time management skills, as well as why those strategies could be helpful for students' future academic and career success.

Students learn App Inventor and other programming languages, but there may be opportunities to enhance CS understanding.

Students following the Technovation curriculum start or continue learning to program using App Inventor. A finalist team from India, participating in their third Technovation Challenge, explained that they continue to return because they learn something new every year, and Technovation gives them the structure to pursue their interests. To further understand what girls learn about computer science during Technovation, we analyzed the computational thinking reflected in apps produced by four returning teams and two first-time teams. The limited sample does not warrant any generalization to the larger group of Technovation participants. Instead, this analysis provides an example of how CS academic achievement might be assessed in future Technovation seasons.

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To inform our analysis, we conducted a brief review of literature[1] on the assessment of projects developed in blocked-based languages like App Inventor. One challenge related to assessing such projects is a lack of a model of novice programming knowledge development or agreed upon rubrics against which assessments could be built. While the field has conducted extensive research around common difficulties and strategies used by novice programmers, it is still unclear how students progress from novices to more experienced learners. Some researchers have noted that students using block-based languages develop habits that go against standard programming practice (e.g., excessive decomposition). A variety of anecdotal, analytical, and empirical approaches have been explored to assess student learning with block-based languages. One review article noted that many assessments rely on highly opportunistic data. In contrast, a researcher at MIT used a corpus of over 200,000 App Inventor projects to analyze programming knowledge and developed a model to explain the phases of programming development users move through. Technovation, with its access to thousands of App Inventor developers each year, is well positioned to contribute to the field's understanding of how students learn blocked-based programming.

Some review articles discussed automated tools for assessing block-based programming projects. We selected von Wangenheim et al.'s Code Master[2] to assess Technovation projects against fifteen criteria. Definitions for the criteria are provided in the Methods Supplement. Code Master is accompanied by a grading rubric that explains the four levels of complexity used to judge each criterion. Each criterion receives a score between 0 and 3 and the scores are summed for a possible maximum for 45 points. A project's total points are divided by the possible maximum points and then multiplied by ten for a grade between 0 and 10. Table 1.2 provides a summary of the scores assigned by Code Master to the six projects we analyzed. Here we highlight a few trends in the scores:

> ***Commonalities across all teams.*** All six teams (a) used two or more screens, (b) changed 75% or more of object names from their defaults, and (c) used more than three types of handlers. Only one team made use of procedures. Nearly all teams used more than one single-dimensional list; no teams used lists of tuples.
>
> ***Differences between returning teams and first-time teams.*** While we cannot make any claims that greater experience with Technovation leads to the use of more computer science concepts, we did notice some differences between the returning teams and the first-time teams in the analysis sample. Namely, first-time teams did not make use of repetition, conditionals, data storage, or operator blocks.
>
> ***Technovation Code Checklist compared to Code Master.*** We noticed some inconsistencies between the information teams provided on their Technovation checklists and the grades produced by Code Master. For example, the Better Me project makes use of lists (see Figure 1.2) but the team did not note this on their checklist. Similarly, no teams checked off loops on their coding checklist, but Code Master identified repetition in three of the projects. One first-time team received a score of 0 for the use of conditionals despite including this on their checklist,

[1] A list of articles reviewed is provided in the Methods Supplement.

[2] CodeMaster Homepage: http://apps.computacaonaescola.ufsc.br:8080/

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TABLE 1.2

Code Master grades for five student projects

	Returning Teams				First-time Teams	
Criterion	**Better Me**	**E-Lab**	**Health Journal**	**Eedo**	**V4**	**TeenVote**
Screens	3	3	3	3	3	3
User interface	3	3	3	3	3	1
Naming of components	3	3	3	3	3	3
Events	3	3	3	3	3	3
Abstraction of procedures	-	-	3	-	-	-
Repetition	3	1	3	-	-	-
Conditionals	3	3	3	3	-	-
Lists	2	2	2	2	2	-
Data storage	2	3	3	2	-	-
Sensors	-	1	-	1	-	-
Media	2	-	2	-	1	-
Social	2	1	-	3	1	-
Connectivity	3	1	-	-	1	1
Drawing and animation	1	-	-	-	-	-
Operators	3	3	3	3	-	-
Grade	7.33	6.00	6.89	5.78	3.78	2.44

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writing, *"the conditional statement was used if the checkbox/button was clicked, it would go to another screen."* The team is describing their use of the when-block, an event handler, while the Code Master tool was only considering if-blocks. It should be noted that while each type of block lives in a different App Inventor Drawer, they share the same gold color suggesting to users they are related (see Figure 1.6).

FIGURE 1.5

Code snippet including a list block (Project: Better Me)

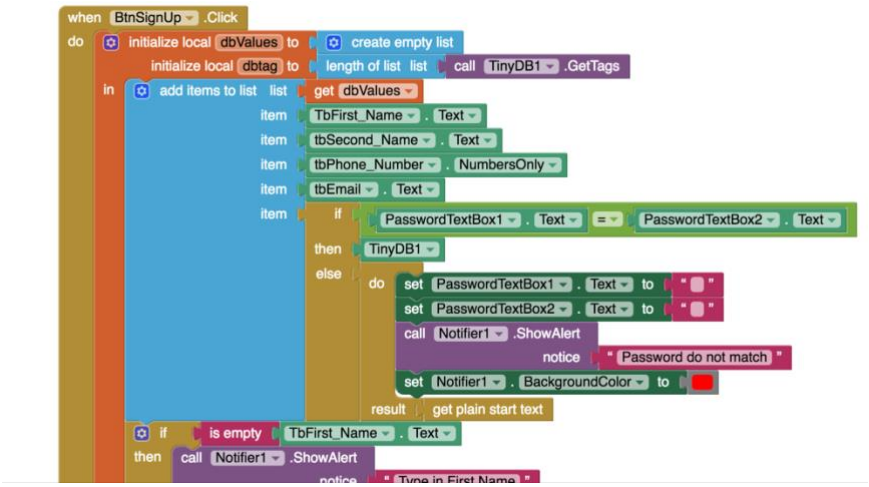

FIGURE 1.6

App Inventor conditional and event handler blocks

In sum, this exploratory analysis demonstrates that in building App Inventor projects for the Technovation Challenge, girls do make use of many programming concepts, but there are key areas (e.g., abstraction) that could be developed more. In considering future assessments of girls' CS academic achievement, a tool like Code Master could help Technovation quickly and consistently evaluate the complexity of projects or identify areas of refinement for the student curriculum. If Technovation decides to make use of Code Master or another similar tool, we suggest they first define the learning outcomes of interest related to computer science and then modify the selected tool's grading rubric to align with goals of the Technovation curriculum.

Lastly, we also want to note that not all Technovation participants use App Inventor. Post-survey responses revealed that 32% of students learned a programming language other than App Inventor as a

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result of their Technovation project. The majority of students (57%) entered Technovation 2018 with prior programming experience in languages such as Scratch, HTML, Java, or Python, which may have influenced their decision to use a platform with which they were already familiar. From our interviews, it appears teams might also decide to use another programming language or platform (e.g., Thunkable, Swift) that they find more accessible, that is accompanied by supporting resources they prefer, or is a part of their school curricula.

Barriers to learning

Below we note potential barriers to learning that teams may encounter during the Technovation season. As these barriers were identified from interview and observation data, further investigation is needed to uncover the degree to which they impact the larger Technovation population.

Time management and group work skills. Time management is a challenge because students often put other responsibilities before Technovation. As one student told us, "*sometimes it is hard to make time for Technovation because I'm taking five classes in school."* Also, some students are inexperienced with employing time management techniques and strategies. These factors can make it difficult for teams to find time to work together. Related to this, some students experience stress when they have to pick up extra work for their teammates. Despite these challenges, one participant advised girls to *'remain in the same group during the season — when groups change, everything falls apart."*

Motivation. Support from family, mentors, veteran team members, and regional ambassadors helped to motivate students to persist through the season. When this support was lacking or removed (e.g., when a mentor dropped out), the Technovation experience felt frustrating and more challenging. Keeping all team members motivated was sometimes difficult because Technovation was not a priority for everyone.

Curriculum. Junior division students had difficulty keeping pace with the Technovation curriculum. Some students and mentors recommended a separate curriculum be created that is more aligned to the needs of the younger age group. Mentors we talked with in Cameroon noted that students drop out of the challenge when the curriculum becomes difficult. Lastly, identifying problems to address and understanding what apps can be developed within the time limits of a Technovation season presented students with a challenge. Even at the World Pitch Night, a team from Uzbekistan noted this as their biggest challenge.

Internet and Computer Access. Teams in Cameroon and Nigeria mentioned Internet and computer access as a challenge for participating in Technovation. For example, although some schools might have a computer lab, they may have a slow Internet connection or limited hours in which students and mentors can access the lab. One mentor discussed spending an entire session helping students set up email accounts because of slow Internet speeds. To address some of these issues, mentors discussed buying girls Internet time at local cafes and bringing modems to schools. It appears that a digital divide exists between the country groups we examined in our analysis. Namely, a smaller percentage of girls in countries outside of the U.S., Spain, Canada, Mexico, Brazil, and India access computers or Internet at their homes (see Table 1.3).

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TABLE 1.3

Girls' home access to computers and Internet

Percentage of girls within each country group who access computers and internet at home				
	U.S.	Spain	Canada, Mexico, Brazil, India	All other countries
Computers[1]	83%	78%	88%	63%
Internet[2]	92%	93%	93%	79%

[1] $\chi 2(3) = 70.78$, $p < .001$; [2] $\chi 2(3) = 45.22$, $p < .001$

Mentors, family and team members are girls' greatest support

During two regional pitch events in the San Francisco Bay Area, we collected 59 junior student responses and 45 senior student responses to the following question: *What was the biggest support to you during the season?* The overwhelming majority of responses ($n_{junior} = 45$, $n_{senior} = 41$) identified particular people who provided encouragement, curriculum support, or logistical support. For example, one participant wrote, *"the biggest support for me during the season came from my sister who is also in my team, Sally, my other teammate, and my mom who drove me and my sister to group meetings and gave us input on our app."* A smaller number of participants mentioned resources from Technovation as their greatest support (n = 8). This included Technovation emails, messages from Student Ambassadors, the curriculum, and examples of prior projects. A handful of girls also wrote about wanting to help others (n = 2), focusing on their final product (n = 1), and YouTube (n = 1). For example, *"The idea of a final outcome has really encouraged me to continue working throughout the entire season. I am so thrilled about our final outcome, and I can't wait for the world to see it."*

Mentors employ various organizational, meeting, and communication strategies when mentoring multiple teams

With an eye towards understanding how Technovation might further support the people that girls rely on so heavily during the season, we examined the strategies mentors used to manage their teams. A subset of open-ended responses from both the pre-season (n = 135) and post-season (n = 125) surveys were selected for analysis. Of these responses, 56 mentors on the pre-season survey and 94 mentors on the post-season wrote about their strategies for mentoring multiple teams. Using an open-coding approach, we identified nine types of strategies:

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Strategy	Definition	Examples
Organization	Employ strategies to keep teams organized and on task	*"I make sure they have a list of tasks to complete and have assigned those tasks to individuals"* *"I plan to use the SWOT technique, Project Management and RAD Software technique."*
Co-mentoring	Working with other mentors (adults and/or students) to support teams	*"I facilitate group work and call coaches to tutor different aspects of the challenge (e.g. technical, business, design...)"* *"Peer mentors using returning members"*
Combine Groups	Congregate teams for joint meetings	*"We will meet as one larger group for the purpose of logistics, then have individual meeting to go over the finer points and needs of each team."* *"I held all the classes at the same time."*
Separate Groups	Meet groups at separate times; work with different types (i.e., in-person, virtual) teams	*"Providing each team the same access to resources, but at different times"* *"I also assign a day specifically to help each team and ensure I always have similar topics or areas to cover with all of them so that I don't get overwhelmed with different things."*
Communication	Determine how to share information and communicate with teams	*"Keep different folders (both physical and digital) with materials needed by girls separated by teams."* *"Inform as many people as possible through social media, like WhatsApp, Facebook, tweeter [sic], and also phone calling."*
Meetings	Allow flexibility in the time and mode (i.e., in-person, virtual) of meetings; meet regularly	*"A combination of both physical and online meetups and mentoring sessions as well as one on one to group mentorship."* *"Regular meetings."*
General Approaches	Strategies applicable to mentoring any number of teams	*"Give them advice and let them know that I was available any time for them to ask me questions about their project"* *"Motivation"*
None	No specific strategy specified	*"To be honest, I'm not sure."*
Other	Strategies not captured by other categories	*"Be equal with both and guide the two teams in the same rhythm"* *"Encourage cooperative work and autonomy"*

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Given the relatively small number of mentors who discussed strategies, we cannot make strong claims about the prevalence of these strategies in the larger mentor population. However, there are interesting trends to highlight. Among pre-season survey respondents, the co-mentoring strategy was mentioned more often by educators than by non-educators and by U.S. mentors than by mentors from other country groups. Educators in the U.S. also discussed ways of combining groups more often than non-educators. We suspect this occurred in Technovation teams based at school sites. Also, returning mentors in the pre-season respondent group discussed keeping groups separate more often than first-time mentors. Among post-season survey respondents, flexibility in the time and mode of meetings was mentioned more by returning mentors than first time mentors and more by mentors in country group 4 (i.e., countries outside of the U.S., Spain, Canada, Mexico, Brazil, and India).

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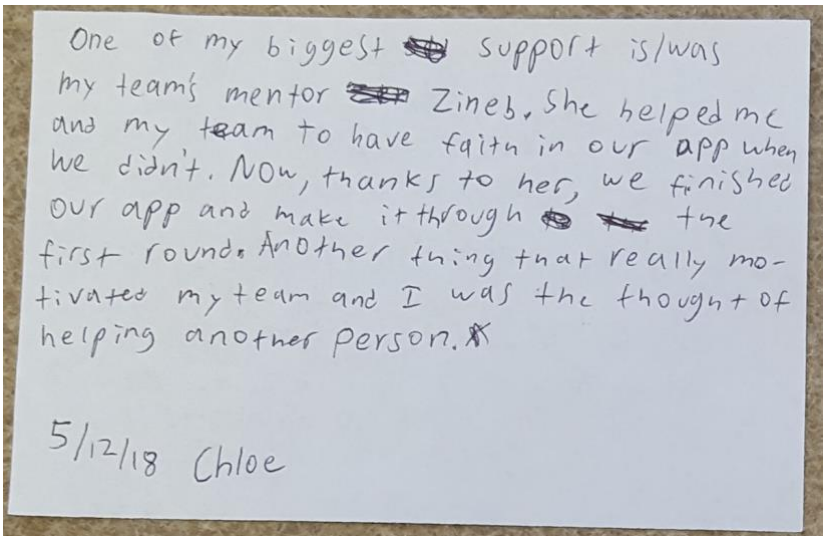
2. Findings about Mentors



Mentors serve a critical role in Technovation. Each season, they devote approximately 50 hours of their time to recruit, supervise, and motivate girls as they complete the Technovation curriculum. When asked why the become Technovation mentors, participants reported that: they enjoy mentoring or educating youth (p_{pre} = 76%, p_{post} = 64%); they want to share their expertise in technology or business (p_{pre} = 64%, p_{post} = 58%); and they want to use tech to solve problems in their communities (p_{pre} = 58%, p_{post} = 47%). Supporting mentors so that they can support girls is vital to the success of the Technovation Challenge.

However, as noted in the Technovation 2018 Registration Report, *"it has been difficult to develop relationships with mentors and build on community engagement because of the community size (2x the size of 2017) and 82% are new."* Our evaluation focused on (a) understanding who are the Technovation mentors, (b) identifying supports they need and if these needs vary based on mentor characteristics, and (c) exploring their beliefs about mentoring and student learning. Data were gathered from 1,369 pre-season surveys (~38% of participants), 477 post-season surveys (~13% of participants), interviews with eight mentors, and an alignment analysis of the fifteen Technovation Mentor Courses. Full details on data collection and analysis methods are provided in the *Methods Supplement.*

Who are the mentors?

Information on mentor backgrounds was gathered on the pre-season and post-season surveys. Since individual responses across surveys were not matched, we report on the profile of both sets of

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respondents. It should be noted that pre-season respondents and post-season respondents may differ in characteristics not captured on the survey that influence the descriptive statistics reported below.

TABLE 2.1

Mentor Countries and Involvement Type

	Pre-season	Post-season
Total countries represented	64	55
Countries with the most mentors	U.S. (186) Spain (161) Canada (106) Mexico (88) India (72)	Spain (78) US (49) India (39) Brazil (32) Kenya (28)
First-time mentors	75%	70%
Second-time mentors	12%	7%
Mentors returning for more than 2 seasons	13%	23%
Mentors with one team	71%	53%
Mentors with multiple teams	28%	41%
Educator by profession	30%	19%

Chi-square tests of independence were calculated to compare the frequency of mentors across four variables: profession as an educator, number of teams mentored, years of experience with Technovation, and country group[3]. Results of these tests are presented on the following page. Most notably, more educators tend to mentor multiple teams and be returning mentors than non-educators. Also, the U.S. has more returning mentors and educator mentors than other countries. Significant differences in these comparisons highlight subgroups of mentors that may be useful to consider in designing future mentor training and supports.

[3] Four country groups were used for analysis. Group 1 = U.S.; Group 2 = Spain; Group 3 = Canada, Mexico, Brazil, India; Group 4 = all other countries. Details on the selection of these country groups is explained in the Methods Supplement.

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Educators mentored multiple teams more than non-educators	
Pre	Educators mentoring 2+ teams: 39% Non-educators mentoring 2+ teams: 24% $\chi^2(1) = 29.17, p < .001$
Post	Educators mentoring 2+ teams: 58% Non-educators mentoring 2+ teams: 41% $\chi^2(1) = 5.65, p < .02$

A smaller percentage of mentors in the U.S. as well as country group 4 (post only) worked with one team	
Pre	Mentors in U.S. with 1 team: 62% Mentors in other countries with 1 team: 73% $\chi^2(3) = 14.03, p < .01$
Post	Mentors in country group 4 with 1 team: 48% Mentors in U.S. with 1 team: 54% Mentors in country group 3 with 1 team: 64% Mentors in country group 2 with 1 team: 72% $\chi^2(3) = 15.24, p < .01$

More first-time mentors are non-educators (post only)	
Pre	(no significant difference)
Post	1st-time mentors who are educators: 58% 1st-time mentors who are non-educators: 72% $\chi^2(1) = 4.41, p < .05$

Unlike other countries, nearly half of U.S. mentors are returning mentors	
Pre	Mentors in U.S. who are returning: 44% Mentors in other countries who are returning: 22% $\chi^2(3) = 75.42, p < .001$
Post	Mentors in U.S. who are returning: 51% Mentors in other countries who are returning: 28% $\chi^2(3) = 34.46, p < .001$

Unlike other countries, nearly half of mentors in the U.S. are educators (pre only)	
Pre	Mentors in U.S. who are educators: 48% Mentors in other countries who are educators: 27% $\chi^2(3) = 53.34, p < .001$
Post	(no significant difference)

More first-time mentors work with just one team than returning mentors	
Pre	First-time mentors with 1 team: 78% Returning mentors with 1 team: 50% $\chi^2(1) = 100.71, p < .001$
Post	First-time mentors with 1 team: 71% Returning mentors with 1 team: 25% $\chi^2(3) = 81.00, p < .001$

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Mentor Skill Set

Mentors rated their experience in several skills related to the Technovation Challenge on a five-point scale with the following levels: no experience (0), novice (1), developing (2), proficient (3), and expert (4). On average, mentors saw themselves as proficient at team building, ideation, project management, and networking. They rated themselves as developing at mentoring youth, pitching, coding, entrepreneurship, marketing, business development, app development, and branding. Among mentors who completed the post-season survey, 46% or more felt they improved in team building, ideation, mentoring youth, and app development.

TABLE 2.2

Mentor self-reported level of expertise

Skill	Pre-season average	Post-season average	% who felt skill improved
Team building	2.73	2.82	47%
Ideation (the formation of ideas or concepts)	2.55	2.73	50%
Project management	2.51	2.67	39%
Networking	-	2.57	31%
Mentoring Youth	2.29	2.34	66%
Pitching	2.06	2.43	39%
Coding	2.04	2.33	39%
Entrepreneurship	2.00	2.23	31%
Marketing	1.91	2.13	31%
Business development	1.80	2.10	35%
App development	1.67	2.09	46%
Branding	1.60	1.91	27%

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Mentor Training and Supports

At the start of the season, mentors wanted supports around their less proficient skills and communication with Technovation.

Pre-season survey respondents described the types of supports they hoped Technovation would provide to improve their ability to serve as a successful mentor. Some mentors wrote about topics in which they would like training: app development (p = 19%), supporting students (p = 7%), and business (p = 4%). For example, one mentor wanted, *"coding tricks for a variety of tasks in AppInventor."* Another mentor wished for *"an example of a good business plan or the process of writing it."* Limited proficiency in certain knowledge and skills may be driving these wishes, as some mentors qualified their responses with statements like *"mainly with regard to my weaknesses"* or *"information about areas I'm less experienced in."*

Several mentors (p = 10%) also expressed expectations around communication with Technovation, wanting, for example, *"someone or an online forum for on-demand help for our specific questions as they come up"* or *"live chats and weekly emails with helpful tips."* Since many of the requested supports already exist, Technovation might consider customizing recommendations for mentors based on their self-reported skill levels. For example, a mentor who rates their knowledge of ideation as developing might be pointed to the *Ideation Unit* course. Or, a mentor who wants support in the form of an online forum can be directed to particular Slack channels.

Online resources and weekly emails kept mentors on track.

Technovation's weekly emails and online resources were frequently mentioned in open-ended post-season survey comments as useful supports ($p_{\text{coding subsample}}$ = 20%). They helped mentors with time management. As one mentor wrote, "*I also appreciate. . . the emails that came into my inbox reminding me of the deadlines or giving me other information. It kept us on our toes."* This sentiment was also echoed by a parent we interviewed shortly after a regional pitch event who said, *"I thought it was very useful that they would send little reminders, like 'this is where you should be at in this point of your app,' they should definitely continue doing that."* Another mentor described how access to these resources provided increased comfort with the mentoring role, *"I also felt confident just knowing that there are tutorials available in case I needed help. . . and I did go to check a few at times to grasp some aspects and be able to move on."*

The student curriculum is widely seen as a helpful resource but could benefit from the inclusion of additional resources.

In general, mentors believed that the student curriculum was effective in providing a starting point for their team. On the post-season survey, the curriculum was most often cited (p = 16%) as the support that improved participants' ability to serve as successful mentors. The curriculum was also rated as having the highest level of benefit to mentors ($\overline{x}$ = 4.27 out of 5). As one mentor wrote, *"Technovation*

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curriculum was the best guide that helped the team." Another mentor complimented it as *"clear and concise."*

However, some mentors stated that the curriculum did not provide sufficient details:

> *It was helpful, but they could add more to the technology part. Thinking from the Technovation side, it's hard because they know not everybody knows about technology, so they try to make it understandable. But I know that all mentors have to investigate on their own how to complete the task because the information in the curriculum is very general as far as what you need to learn and deliver. I heard a lot of questions from other mentors.*

Mentors explained how they supplemented the curriculum with a variety of external resources and examples, most frequently referencing YouTube videos. Others requested resources related to programming platforms beyond App Inventor. As one mentor wrote on the pre-season survey, *"we are an iOS school and need to use Thunkable but there are limited resources."* Technovation already provides instructional videos that mentors appreciated. For example, several mentors commented on the value of videos showing the pitching process. However, mentors suggested that Technovation produce more of their own videos and tutorials, specifically to provide guidance on App Inventor.

In addition to providing more resources and videos related to App Inventor, mentors requested additional information about the debugging process, entrepreneurship, and how to edit the pitch video. One mentor suggested adding an FAQ at the end of every lesson to answer common questions and provide further details. Another recommended adding resources on the website identifying typical coding problems and providing solutions. Finally, one mentor highlighted that debugging, although frustrating for her team, is a standard computer science practice. She explained that it would be helpful to include a lesson about debugging in the curriculum, "*to emphasize the fact that real computer science involves a lot of debugging even for adults, and that's okay and that's how it works- that's one of the joys of programming. Debugging and finding that problem is a big win no matter your level."*

Mentor supports, including Slack and online courses, could benefit from further development.

Course Alignment Analysis

Technovation offered mentors support through a set of fifteen online courses and multiple Slack channels. We first conducted an analysis of the online courses to determine the degree to which courses align with research on effective professional learning programs. Six criteria were considered: focus on content knowledge, opportunities for active learning, coherence with the goals of Technovation, sufficient duration of activities, collective participation, and opportunities to reflect on beliefs about mentoring and learning. Each criterion was rated on scale of low, medium, high (see Table 2.3).

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TABLE 2.3

Alignment Analysis Rating of Online Courses

Criterion	Definition	Level of Alignment
Coherence	Mentor training is consistent with Iridescent's theory of change (i.e., building curiosity, creativity, perseverance, problem solving, communication, collaboration)	High
Duration	Training activities are of sufficient duration, including both span of time over which the activity is spread and the number of hours spent in the activity	High
Beliefs about mentoring and learning	Opportunities are available for mentors to reflect on their ideas about how best to support students and how students learn; student-centered beliefs about teaching/learning are promoted	Medium
Active learning	Opportunities are available for mentors to get involved (e.g., observing expert mentors or being observed; reviewing student work; and leading discussions)	Low
Collective participation	Groups of mentors from similar contexts (e.g., region, division) participate together and build an interactive learning community	Low
Content knowledge	Training materials focus on Technovation subject matter content (i.e., programming and entrepreneurship) and how students learn that content	Low

The online courses were rated high on the coherence criterion because nearly every course included a focus on one or more of the competencies and characteristics defined on Iridescent's Theory of Change. For example, *Asking Open-Ended Questions & Fostering a Growth Mindset* addressed ways of building a child's self-efficacy and avoiding gender bias. As another example, *Business 2: Market Research* provided coherence with a perseverance attitude with a focus on celebrating small wins. Courses were also rated high on duration because there are sufficient courses to span across the Technovation curriculum. It should be noted that the time required for a WestEd evaluator to complete each course, including a review of external resources, varied widely from 3 minutes to 36 minutes.

The courses were rated medium on the beliefs criterion because approximately a third of courses included material aligned with constructivist beliefs about mentoring and teaching that are promoted by Iridescent. For example, *Code 2: Data and Variables* provides a list of learning strategies mentors can share with students, includes strategies to encourage accountability in students, and offers readings focused on allowing students to make plans for their own success.

The courses received low ratings for providing little or no opportunity for active learning, collective participation, or a focus on content knowledge. A couple of courses contained activities that leaned towards active learning such as (a) asking mentors to create statements they might say to a student who

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is struggling or (b) asking mentors to reflect on course material. However, no feedback on the activities is provided. Concerning collective participation, the courses contain a discussion feature where participants can leave comments. However, no comments were noted in any courses. Collective participation is partially encouraged through written advice provided by students and adults, but these tips are asynchronous and do not allow for a dialogue with participants.

We also evaluated courses for the level of content knowledge they provided related to the topic areas covered in the Technovation curriculum (i.e., coding and business) and saw very little support related to the subject matter. For example, the only content covered in some courses was a vocabulary list related to the corresponding student curriculum unit. So, we rated this criterion low. However, in discussing our analysis with Technovation, we learned the courses were designed to support mentoring more generally. Revising current course titles and course summaries may help to clarify the goals of each course.

Mentor Feedback on Courses and Slack

Of the 340 survey respondents who answered the question 'how many of the online Technovation Mentor Training courses did they take', the majority reported completing half or more of the courses focused on coding (p = 65%), business (p = 63%), or ideation, pitching and team support (p = 72%). Most of these respondents also reported the courses increased their confidence to mentor teams in the related topics to some degree.

However, nearly a third reported not completing any of the courses and nearly another third said the courses did not improve their mentoring confidence. Most of the mentors we interviewed were confused when we asked them whether they had taken any of the online courses, and several mentors said they didn't know they existed. Only one out of the eight mentors interviewed was definitive about her use of the courses, but she explained that she *"found them very light with the information that they provide."* She recommended that the courses be reworked to provide more in-depth information and training in computer science and coding skills.

This mentor also suggested that instead of keeping the focus solely on motivating girls, Technovation should help mentors realize how much they can gain from their experiences and how much they are valued. She explained that other mentors she met struggled greatly with coding challenges because they lacked computer science experience, which decreased their motivation to be involved in the season. She noted the importance of mentors receiving training, education, and support from Technovation, because right now she believes the mentors *"feel a little invisible."*

Similarly, another mentor commented that the mentor handbook was not helpful because the *"information was too general— not enough details. It just gave the schedule and suggested curriculum timeline."* Based on feedback from the mentors, adding more information, tips, and coding lessons to these two resources would be useful; the online courses should be featured more prominently on the Technovation website or in materials provided to mentors so that they know this resource is available.

Concerning the Technovation Slack channels for mentors, some interview participants commented that they served as a helpful resource for asking minor questions and staying abreast of Technovation

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deadlines. This was also confirmed by a small number of survey respondents who, when asked what supports improved their mentoring success, wrote about the Slack channels (n = 6). However, one interviewee noted that the Slack channels would be much more helpful if they were divided into separate channels based on the topic, such as one channel related to coding issues, one related to questions about the pitch process, and another to discuss marketing and entrepreneurship. While one of these channels already exists (i.e., *appinventor*), further separation of the *girlscurriculum* channel might prove useful. This would provide a clearer resource for mentors about where to go to discuss their issues, since some mentors may not otherwise feel comfortable posting specific, detailed questions in such an open-ended forum.

Separating out the Slack channels may also decrease the message response time. One mentor explained that she posted urgent questions about coding challenges in the final month before pitch submissions were due, and the team often waited two or three days before anyone provided a response. The team was working intensively at the time to finish their app, and they found it difficult to wait several days for Slack responses since they did not know where else to go or whom else to contact for assistance.

In-person events such as those organized by Regional Ambassadors were cited as highly beneficial for mentors.

Mentors who attended meetings, workshops, and other events in their area uniformly praised and appreciated these opportunities. This was consistent in both interviews and post-season survey responses. One interviewee from Uzbekistan explained that in her country, *"they have great pre-season, during season, and post-season meetings, and it was amazing to meet with other mentors and speak to them about their problems, apps, and solutions."* Another mentor reflected on the value of a workshop organized by their Regional Ambassador: *"At the workshop they talked about everything to do with the curriculum: how to start, how to cover the phases, how to get started with the app. That was definitely helpful. We were able to interact with other mentors and learn what type of problems they are having."*

Serving as an online mentor presents more significant challenges to involvement and engagement in the Technovation program.

Of the eight mentors we interviewed, those who mentored teams from a distance (online) expressed the most challenges with staying engaged in the Technovation program and communicating with their participants. One of these mentors had her team disband partway through the competition. She suggested that it would be helpful for Technovation to include more structure for virtual mentors and teams, including providing a platform—or, at the very least, guidance—for distance-based teams about how to communicate. Furthermore, it would be helpful for Technovation to build up more support, resources, and structure for online mentors as well as their teams, so that these participants have the opportunity to feel more connected to each other, to other teams and mentors working in a similar online format, and to the Technovation program as a whole. One simple support that could be offered immediately might be to provide a Slack channel dedicated to online mentors so that they can connect and communicate with each other, since they may face similar challenges.

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Beliefs about Mentoring and Student Learning

Mentors hold mostly constructivist beliefs of mentoring and learning.

Beyond skills, knowledge, and Technovation supports, other factors can influence the mentoring experience. For example, beliefs about the role of a mentor and beliefs about how students learn can influence the choices a mentor makes about how to support their teams. These beliefs can also influence the ways in which mentors seek and respond to supports provided by Technovation. Research in this topic places beliefs on a spectrum ranging from more teacher-focused, didactic beliefs to more student-focused, constructivist beliefs. Didactic beliefs view teachers (i.e., mentors) as conveyers of knowledge. Iridescent's theory of change aligns more with constructivist beliefs that view students as constructors of their knowledge and teachers/mentors as facilitators of this process.

We conducted an exploratory analysis into mentors' beliefs by asking them to rank two sets of statements. One set asked how they determine when students are understanding, and the second set asked how they view their role as a mentor. Here we present the statements, with more constructivist beliefs at the top (indicated by a higher E score) and more didactic beliefs at the bottom (indicated by a lower E score):

How do you know when your team understands the Technovation curriculum?
When they can create something new without my help. [E5]
When they are helping or teaching each other. [E4]
When they ask questions or make connections to other parts of the curriculum. [E3]
When I ask questions and see if they are getting it. [E2]
When they are paying close attention to the lessons. [E1]

How would you describe your role as a mentor?
My role is to create an environment for my team to take charge of their own learning. [E4]
My role is to develop a good relationship with my team(s) so that they feel comfortable participating. [E3]
My role is to provide my team(s) with experiences in coding and entrepreneurship. [E2]
My role is to deliver information to my team and provide instruction. [E1]

When looking across all survey respondents, we found that constructivist beliefs (those with greater E values) were ranked more highly for both sets of statements. When looking at responses by mentor characteristics, we noticed a slightly different pattern in how mentors from country group 4 (i.e., all countries outside of the U.S., Spain, Canada, Mexico, Brazil, and India) ranked statements about their role as mentors. Amongst these mentors, most (p = 30%) selected E3 as the statement they most agreed with and most (p = 28%) selected E1 (a didactic belief) as the statement they ranked second in their level of agreement.

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So, it appears that participants are more varied in their beliefs about the role of a Technovation mentor than in their beliefs about student learning. During our interviews, we noticed how some mentors came to distinguish teaching from mentoring because of their experiences. For example, one mentor described teaching as more didactic and mentoring as more constructivist:

> *"I am a teacher of English…and it was easy for me to teach someone, but mentoring was new for me, because. . . it should be supporting not teaching. Because the girls are not so young and not so old, and you can support them, not teach them. You can explain them something to do but not to teach them. They should try to find solutions themselves but if they cannot, you can explain. . . how to find the solutions. I think mentoring is harder."*

In contrast, another mentor described an epistemological belief that values the transmission of information from mentor to student:

> *"I figured I would be like a support person to help the girls along, put them on a schedule, to keep them on the schedule. . . So, it's more of a supporting role for the girls and an administrative role in terms of keeping them on track, and to have the checklist of everything, that they actually hit all the benchmarks, and say 'okay, you know, I did this, I did that.' So that's the way I saw myself. Just getting the girls moving, getting their ideas to move forward, and connecting with them in that way."*

Given the varying beliefs mentors hold about their role in the Technovation Challenge, mentors might be looking for different supports from Technovation. For example, the mentor quoted above might find the Technovation checklist and weekly emails most useful but be less interested in mentor courses focused on strategies to motivate learners. It should be noted that this analysis into mentors' epistemological beliefs was exploratory in nature. Beliefs are complex. People often hold multiple, sometimes conflicting, beliefs that depend upon the contexts within which they find themselves. We are not suggesting that certain beliefs should be encouraged more than others. Rather, we offer this analysis as a way to better understand, and therefore better cater to, the needs of the Technovation mentors.

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3. Recommendations

Overall, Technovation continues to offer girls across the world meaningful learning experiences that build their confidence and interest in CS, business, and entrepreneurship. Mentors praised Technovation, noting how the girls benefitted from participation. As one mentor told us: *"We are so thankful for Technovation—it's a life-changing experience for those girls. This is something that they'll remember forever and that's something that they emphasized at the end. At the beginning they just wanted to play games, but by the end of [Technovation], they were hooked."* During this evaluation, we identified a few areas Iridescent might consider attending to in future seasons to improve the experience for more Technovation participants, namely: student motivation, programming knowledge for both mentors and students, and mentor awareness of Technovation resources. The recommendations below are suggestions from both WestEd and Technovation mentors to address these areas of improvement.

Develop additional ways to motivate girls

While many girls successfully complete the Technovation season, some do not. As one student commented,

> *At the start of this semester we had five groups entering the competition, but in the end we only had two groups and only one that completed all the tasks and requirements (us). It's a shame that all the people left because they didn't try out the coding. Maybe it was the meeting time which took away all our lunch time or it was lack of motivation from peers. I think it is essential that the mentors are the ones that run the course and that they know us and make us feel included.*

Girls may need additional supports in the season to sustain their motivation. One mentor suggested offering rewards for those competing at the national level and allowing them to share their apps in a public venue (e.g., Google Play). Another mentor requested adding more local events aimed at students: *"Workshops would be helpful. . . so that the students can get help in person. What to put on their videos, what not to put; how to work on entrepreneurship, how to design their logo. We had a workshop for the mentors but not for the girls."* It should be noted that these types of opportunities for participants already exist in some regions, such as the San Francisco Bay Area.

Mentors also offer a wealth of motivation for girls, but some teams are matched with uncommitted mentors. As one student commented, *"I really loved Technovation, but my team's previous mentors were not helpful and didn't participate. We acquired new mentors that helped us near the end of the process."* Where possible, temporary mentors might prove useful for teams in this situation. This could take the form of a person, or set of people, who send encouraging words to girls and guide them to resources to continue with their projects until new mentors are found.

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Make college and career readiness an explicit focus

Some mentors we interviewed told us they had not discussed college plans or career aspirations with their participants. Nevertheless, they all stated including this topic in the Technovation curriculum could prompt mentors to have purposeful discussions with their students about thoughts and plans for the future. Iridescent might further develop its curriculum to provide more explicit guidance to participants on the importance and worth of time management skills, as well as why those strategies could be helpful for students' future academic and career success.

Centralize mentor supports and increase programming resources.

Mentors have access to many resources to help them during the season (e.g., Slack, student curriculum, mentor courses). Their work could be simplified by combining these resources. For example, a mentor curriculum book could be created that mirrors the student curriculum but embeds relevant mentor courses and links to related Slack channels.

Although prior programming experience is not a requisite for mentoring, some mentors wanted more training on this topic. Based on feedback from mentors we interviewed, adding more information, tips, and coding lessons to the curriculum would be useful. Including examples of student work could also help mentors to prepare for the difficulties their teams might encounter.

Restructure Slack channels.

While several Slack channels already exist, one mentor suggested ideas for additional channels that focused on more specific topics (e.g., pitch process, marketing). Another mentor discussed waiting several days for responses during a critical time in her team's project. Narrowing the channels, either in topic or in number of participants, might make the forums more usable. This would provide a clearer resource for mentors about where to go to discuss their issues, since some mentors may not otherwise feel comfortable posting specific, detailed questions in such an open-ended forum. Also, Slack channels for mentors with similar characteristics (e.g., virtual mentors, first-time mentors) can provide a safe space to give and receive support, since discussants may face similar challenges.

Continue offering mentor supports but develop ways to help mentors discover the supports most relevant to their needs.

Comments from mentors suggests that some are unaware of all the supports provided by Technovation. Technovation might consider providing customized recommendations for mentors based on their self-reported skill levels or their needs. For example, a mentor who rates their knowledge of ideation as developing on the pre-season survey might be pointed to the *Ideation Unit* course. Or, a mentor who wants support in the form of an online forum can be directed to particular Slack channels. As another example, mentors indicating that they are working with multiple teams might be directed to materials on how to manage communication across many teams.

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Mentors invited to the World Pitch offered feedback on event logistics.

A mentor from outside the United States described significant challenges in getting visa appointments for her team to attend the World Pitch within the allotted the time frame. She explained, *"There are only 30 days to get everything together to travel. The visa appointments usually take 30 to 35 days to get. We called every single day to try to get in earlier. It was very stressful. I even lost weight during that time. It should be 2 to 3 months between [the announcement of the winners and the World Pitch] at least."*

Two mentors also independently commented that the participants' schedule on the day of the World Pitch was too exhausting for their teams due to multiple field trips with little time to rest. The girls would have liked more time to practice and to relax before the big event, but the day was so busy that it felt like *"the girls don't even have time to breathe."*

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