Youth Teamwork Skills Survey:
Manual and Survey

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OVERVIEW

Twenty-first century skills are vital for preparing our nation's youth to become tomorrow's innovators, researchers, and leaders in the science, technology, engineering, and math (STEM) fields. STEM out-of-school time (OST) programs play an important role in helping youth develop the 21st century skills they need to prepare them for the workforce, particularly the teamwork skills necessary for the growing collaborative nature of work in STEM (National Research Council, 2015). However, there is a lack of appropriate tools to evaluate this key programmatic outcome in STEM OST settings. Many evaluators of middle and high school STEM OST programs need to develop their own data collection tools, modify existing tools, or use ones that lack appropriate validity evidence for the population and/or context being studied. Through funding from the National Science Foundation, we carried out the Collaboration in the 21st Century (C2C) project to help address this need by developing and validating a survey, the Youth Teamwork Skills Survey, to measure the teamwork skill of team communication in middle and high school STEM OST programs. The development and validation process for the Youth Teamwork Skills Survey resulted in a survey that evaluators can be confident will gather reliable data, has adequate validity evidence for use with STEM OST programs, and is grounded in what actually occurs in these programs (see Appendix C for technical details of the survey).

> **A team is "two or more individuals with different roles and responsibilities who interact socially and interdependently within an organizational system to perform tasks and accomplish common goals" (National Research Council, 2015, p. 2).**

WHAT TEAMWORK SKILL AREA DOES THE SURVEY FOCUS ON?

Most of the literature detailing teamwork skills comes from fields outside of out-of-school time such as formal education and organizational psychology. In order to create a survey appropriate for the way teamwork skills are defined in STEM OST programs and ensure the survey's usefulness, it was important to ground the survey and what was measured in the way teamwork skills are operationalized in STEM OST programs. We needed to understand what teamwork skills STEM OST programs are addressing or want youth to exhibit in their programs. To find this out we interviewed practitioners from 34 STEM OST programs from across the country. The construct, or trait, of **team communication skills** was selected because team communication was the teamwork skill STEM OST practitioners (75% middle school, 91% high school) most frequently identified as an important outcome of their programs. Team communication skills are not only important STEM OST program outcomes, they are vital skills to prepare youth to effectively participate as a member of a team in the STEM workforce.

HOW ARE WE DEFINING TEAM COMMUNICATION SKILLS?

The definition of team communication skills used for this survey was developed by pulling from the STEM OST practitioner interviews and relevant literature. The definition is composed of three team communication skill areas: (a) closed-loop communication, (b) information exchange, and (c) listening.

Closed-loop communication

Closed-loop communication is the communication process between the sender and receiver of a message to make sure a message is communicated, received, and understood (Johnson & Johnson, 2013; McIntyre & Salas, 1995; Salas, Rosen, Burke, & Goodwin, 2009). The sender needs to ensure that the other person received the message and interpreted it correctly, and encourage the receiver to clarify understanding by repeating back what they heard and asking clarifying questions; while the receiver needs to acknowledge they have received the information, repeat back what they heard, and if necessary, ask clarifying questions to make sure they fully understand what is being communicated (Dickinson & McIntyre, 1997; Johnson & Johnson, 2013; McIntyre & Salas, 1995; Rosen et al., 2013; Salas et al., 2009).

Information exchange

The exchange of information and ideas is key for a team to effectively work together toward a common goal (Aube, Brunelle, & Rousseau, 2014). Team members each have important knowledge and ideas and part of the skill is knowing when to share them, what is important to share, and doing so without being asked (Salas, 2013; Smith-Jentsch, Cannon-Bowers, Tannenbaum, & Salas, 2008; Smith-Jentsch, Johntson, & Payne, 1998). Of particular emphasis is recognizing and sharing "unique" information with the team, even if it differs from what someone else has shared (Salas, 2013).

Listening

The ability to listen effectively is an important part of strong team communication skills (Baker, Horvath, Campion, Offermann, & Salas, 2004). Listening includes the skills of knowing when to listen, being an active listener, balancing listening and speaking, and avoiding interrupting teammates (Greenstein, 2012; Organization for Economic Cooperation and Development, 2005).

WHAT IS THE FORMAT OF THE SURVEY?

The Youth Teamwork Skills Survey is a self-report survey that measures youths' perceived team communication skill level and their comfort, ease, and likelihood of using the skill. The survey is composed of an imaginary teamwork scenario that provides the framing for responding to the survey's questions. The survey includes 28 items, or questions, that fall into five factors based on the team communication skill areas of closed-loop communication, information exchange, and listening. The survey can be found in Appendix A.

Scenario

Since STEM OST programs differ widely in terms of their content and activities, we created a context for the survey that would make it relevant and useful for a wide range of programs. A teamwork situation, or scenario, was developed for youth to imagine themselves in while responding to the survey questions. The scenario was created based on how team experiences were described in STEM OST practitioner interviews and in the literature on effective teams. The scenario was written to be general enough that youth in a wide variety of programs could see themselves in it. You can see the scenario on the first page of the survey in Appendix A.

Customization

The scenario, instructions, and a few items can be customized, which are indicated by brackets [ ] around the words. You can input your STEM OST program name [program], indicate the grade level of the youth taking the survey [middle school or high school], and customize the kind of activity the team is working on together [program or challenge]. The rest of the survey should be administered as written.

Items

The items were developed by looking at the STEM OST practitioners' interview data, literature definitions, and items from other measures with an effort to make sure the items adequately covered each team communication skill area. The items fall into five distinct factors, or skill areas, of team communication skills – two information exchange factors, two closed-loop communication factors, and one listening factor. The next page outlines which items fall underneath each factor.

Response options

All 28 items have response options based on a four-point scale. The closed-loop communication and information exchange items are structured so there is an anchor statement with three follow-up questions where youth rate how good or bad they would be at doing the skill, how comfortable or uncomfortable they would be doing it, and the likelihood they would do it on the imaginary team. For the listening factor, youth respond to each statement in terms of how easy or hard it would be to do that skill.

TEAM COMMUNICATION SKILL AREAS COVERED BY THE SURVEY ITEMS

*The bulleted statements under each factor, or skill area, are the survey items that youth rate.

Closed-Loop Communication Factor 1

Closed-loop communication items related to a teammate's idea.

- Asking your teammate to explain their idea in a different way so you can understand it better.
- Asking your teammate to repeat their idea because you are unsure if you understood it correctly.

Closed-Loop Communication Factor 2

Closed-loop communication items related to youth's own idea.

- Asking your teammates if they understand your idea.
- Encouraging your teammates to ask you questions about your idea to make sure they understand it correctly.

Information Exchange Factor 1

Information exchange items that are about youth sharing their information/idea with the team.

- Sharing information you found about the topic of the [project/challenge] that none of your teammates have mentioned yet.
- Explaining an idea you have to the team.

Information Exchange Factor 2

Information exchange items about bringing up an idea that might be more difficult to share.

- Sharing an idea even if you think your team might dislike it.
- Bringing up an idea for the [project/challenge] that is different from the idea the team just finished discussing.

Listening Factor

- Stay focused on what a teammate is saying when you would rather be working on your part of the team project.
- Listen closely to a teammate share an idea instead of focusing on what you are going to say to the team about your own idea.
- Fully focus on what a teammate is saying instead of thinking about what you are going to say next to the team.
- Stay focused on the conversation your team is having instead of letting your mind wander.

WHO IS THE SURVEY MEANT TO BE ADMINISTERED TO?

The Youth Teamwork Skills Survey is meant to be used with youth in grades 6-12 participating in STEM OST programs that use team structures in their programming. The survey was tested and validated with this population. If you plan to use the survey with other ages of youth or with adults it is highly recommended that you gather validity evidence for use with those audiences.

> **The survey is for youth in Grades 6 – 12 participating in a STEM OST program that uses a team structure during some part of their programmatic activities.**

WHAT CONTEXT OR SETTING IS THE SURVEY MEANT FOR?

The Youth Teamwork Skills Survey was developed, tested, and meant to be used with STEM OST programs across the United States that use a team structure during some part of their programmatic activities. STEM OST programs include a wide range of programs that happen before school, afterschool, on weekends, and in the summer. These include camps, clubs, teen volunteer programs, youth development programs, youth employment programs, internships, research experience programs, afterschool classes, drop-in programs, competition-type programs (robotics or design), and more.

WHAT DO I NEED TO KNOW ABOUT ADMINISTERING THE SURVEY?

- It takes youth around 5-10 minutes to complete the survey.
- The survey can be administered on an online survey platform or on paper.
- The survey is not meant to be administered right when youth start a program. The scenario has youth imagining themselves in their program, so you'll want to make sure youth have enough experience with the program (at least a few sessions) to be able to imagine themselves in the program before you administer the survey as a baseline or pre-measure.

DO I HAVE TO ADMINISTER QUESTIONS FROM ALL FIVE FACTORS?

No, you can decide which factors are important to measure for the program's evaluation. Through a process of confirmatory factor analysis, we gathered internal structure validity evidence that team communication skills fall into five distinct skill areas or factors (two information exchange factors, two closed-loop communication factors, and a listening factor). Each of the factors are scored separately so you can administer questions from only one to all five factors. Appendix B has a breakdown of what questions are included in each factor to guide you on what questions to keep or remove from the survey depending on which team communication skill area(s) you want to measure. No matter how many factors you decide to include in the survey, always include the first page of the survey (the scenario and survey instructions) and make sure the questions you keep in remain in the order they appear in the survey.

HOW DO I SCORE THE SURVEY?

The survey is composed of five different factors or skill areas. Youth do **not** receive one score for the entire survey, instead they receive **scores for each of the five factors** that break down their perceived team communication skill level into different skill areas. To evaluate a program, the factor scores for each youth are averaged to provide a program-level factor score. This allows STEM OST providers to better understand the team communication skill areas where the youth are doing well in the program and where they could use support to improve their team communication skills.

The individual questions are scored based on the response options. Scores for an individual question range from 1 to 4. Table 1 provides an example of how one of the listening items is scored. See Appendix B for the suggested values for the response options for each question.

Table 1. Sample scoring for the response options for one of the listening items

Stay focused on what a teammate is saying when you would rather be working on your part of the team project.	
Hard to do this	Score = 1
Kind of hard to do this	Score = 2
Kind of easy to do this	Score = 3
Easy to do this	Score = 4

A factor score is first created for an individual youth by adding up the individual scores for each of the items in a factor and dividing that total score by the number of items in the factor. Appendix B indicates which items go into each factor. For example, the listening factor has four items so to compute the factor score for an individual youth you would add together the scores for the four items in that factor and then divide that total score by four (the number of items). Table 2 indicates the total score range for each factor, how many items are in each factor, and the average factor score range (all factors have the same average score range because they all have four response options).

Table 2. Total score range for each factor, number of items in each factor, and average factor score range

Factor	Total score range	Number of items in the factor	Average factor score range
Information Exchange Factor 1	6 to 24	6 items	1 to 4
Information Exchange Factor 2	6 to 24	6 items	1 to 4
Closed-Loop Communication Factor 1	6 to 24	6 items	1 to 4
Closed-Loop Communication Factor 2	6 to 24	6 items	1 to 4
Listening	4 to 16	4 items	1 to 4

Scoring example

Below is an example of how someone might respond to the four listening factor items. In parentheses is how you would score that response. In this case, the listening factor total score for this individual would be 1 + 3 + 2 + 4 = 10. You would then get the average listening factor score for that youth by dividing their total factor score by the number of items (Average Listening Factor Score = 10/4 = 2.5).

	Hard to do this	Kind of hard to do this	Kind of easy to do this	Easy to do this
Listen closely to a teammate share an idea instead of focusing on what you are going to say to the team about your own idea.	X (1)	☐	☐	☐
Stay focused on the conversation your team is having instead of letting your mind wander.	☐	☐	X (3)	☐
Fully focus on what a teammate is saying instead of thinking about what you are going to say next to the team.	☐	X (2)	☐	☐
Stay focused on what a teammate is saying when you would rather be working on your part of the team [project/challenge].	☐	☐	☐	X (4)

HOW DO I ANALYZE THE SCORES?

For program evaluation purposes, you'll want to analyze aggregate factor scores of youth in the program. After you've computed average factor scores for each youth, you'll use those values to calculate an average factor score across all the youth in the program. You can also compare average factor scores across subgroups of youth (e.g. grade level, gender, etc.) to see if there are differences in perceived team communication skills by subgroups. Additionally, you can create a histogram of the individual values to look at the spread of factor scores across youth in the program. It is important to note that as a self-report survey this is not a direct measure of team communication skills, so the interpretation of scores should be framed as youths' "perception" of their team communication skill level.

HOW CAN I USE THE SURVEY FOR EVALUATION?

The survey can be used for formative evaluation purposes to inform program improvements to help youth further develop their team communication skills. It can also be used for summative evaluation as a pre-post measure to look at program impact on team communication skill development. This would give insight into how well the survey measures change over time in youths' perceptions of their skill level, and their comfort, ease, and likelihood of using the skill. It is important to note that the survey was tested at one time point during a program, not as a pre-post summative evaluation measure, so additional validation work should be done around that particular use of the survey.

WHAT ABOUT RELIABILITY AND VALIDITY EVIDENCE FOR THE SURVEY?

Reliability

Reliability of responses was addressed through the development and testing of the items and checked statistically by computing coefficient alpha. STEM OST practitioners and youth in STEM OST programs provided feedback on the items and scenario to ensure that items were clearly interpreted and measuring what was intended. Coefficient alphas for each of the five factors were at or above $\alpha = .70$ ($\alpha = .70$ to .79), providing evidence of the reliability of the factor scores for the five factors (DeVellis, 2012). See Appendix C for more details about the reliability of responses.

Validity evidence

Various types of validity evidence were collected in order to make the argument that the interpretation of factor scores on the Youth Teamwork Skills Survey are indeed measures of youth's perception of their team communication skill level, their comfort and likelihood of performing the skill, and, in the case of the listening factor, how easy it would be for them to use the skill. The validity argument includes construct validity evidence based on content, response process, and internal structure (American Educational Research Association, American Psychological Association, & National Council on Measurement in Education, 2014; Messick, 1995). Content-related validity evidence was gathered by reviewing the literature and gathering feedback from STEM OST practitioners to ensure that the content of the survey aligned with the construct of team communication skills. Think-aloud interviews were carried out to gather response process validity evidence (Wilson, 2005). Internal structure validity evidence came from factor analysis and differential item functioning (DIF) analysis (American Educational Research Association et al., 2014). See Appendix C for more information about each type of validity evidence gathered for the survey.

If you'd like to read a more detailed discussion about the development and validation of the Youth Teamwork Skills Survey, see Amy Grack Nelson's (2017) dissertation, "Development and validation of a survey to measure perceived team communication skills in middle and high school STEM out-of-school time programs." Contact Amy Grack Nelson at agnelson@smm.org to request a copy.

Gathering additional validity evidence

If you are using the survey with a population other than youth in grade 6-12 and a context outside of STEM OST programs, you'll want to gather your own validity evidence to ensure the construct of team communication skills is still defined the same way, the items are relevant to the population and context, and the items still work as intended. As mentioned earlier, if you are using the measure for summative evaluation purposes, you'll also want to gather evidence for using the survey as a pre-post measure.

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APPENDIX A: YOUTH TEAMWORK SKILLS SURVEY

First read the Teamwork Scenario below. You will want to keep this imaginary team in mind as you answer the questions in the survey.

Teamwork Scenario

Imagine you are in the [program name] and have just been placed in a team to complete a [project/challenge] together. There are two other youth on the team, one girl and one boy, so there are three of you total. All three of you are in [middle/high] school. You met your teammates for the first time today. Before working on your [project/challenge] together, you all participated in an activity where everyone in the program shared their name and five interesting facts about themselves.

Your team reviews the details of the [project/challenge] and makes sure everyone on the team understands what they need to do. Then team members share with each other what they already know about the [project/challenge] topic. As a team, you decide that you all still need to learn more about the topic. The team members split up to find information by searching online, reading books or magazines, or looking at information provided by your program. After everyone has done some research, the team comes back together, and team members explain what they learned. Your team then starts to share and discuss ideas about what they might need to do to complete the [project/challenge]. The team decides what tasks need to be done, who will work on which tasks, and then gets to work. Team members work on tasks both together and alone. Completing the final [project/challenge] is dependent on everyone's contributions so team members are constantly checking in with each other to make sure the team is on track to reach their goal.

Throughout the survey, you'll be asked to imagine yourself doing lots of different things as a member of the imaginary team described in the Teamwork Scenario. Please answer the survey questions openly and honestly about what you might do as part of this team. There are no right or wrong answers to the questions and you aren't graded on them.

On the following pages, you'll see a statement followed by three questions. Imagine yourself doing what the statement says as a member of the imaginary team. You will be asked how good or bad you think you might be at doing what the statement says, how comfortable or uncomfortable you might be doing it, and how likely or unlikely it would be that you would actually do it on the imaginary team. Remember, the imaginary team is only you and two other people in your program.

The first thing for you to think about doing on the imaginary team is:

Sharing information you found about the topic of the [project/challenge] **that none of your teammates have mentioned yet.**

1) How good or bad do you think you would be at doing this on the imaginary team?
   - ☐ Bad at this
   - ☐ Kind of bad at this
   - ☐ Kind of good at this
   - ☐ Good at this

2) How comfortable or uncomfortable do you think you would be doing this on the imaginary team?
   - ☐ Uncomfortable doing this
   - ☐ Kind of uncomfortable doing this
   - ☐ Kind of comfortable doing this
   - ☐ Comfortable doing this

3) How likely or unlikely would you be to actually do this with the imaginary team?
   - ☐ Unlikely to do this
   - ☐ Kind of unlikely to do this
   - ☐ Kind of likely to do this
   - ☐ Likely to do this

For the following statements, imagine you are sharing ideas about the [project/challenge] with your two teammates in the imaginary team.

The next thing for you to think about doing on the imaginary team is:

Explaining an idea you have to the team.

4) How good or bad do you think you would be at doing this on the imaginary team?
   - ☐ Bad at this
   - ☐ Kind of bad at this
   - ☐ Kind of good at this
   - ☐ Good at this

5) How comfortable or uncomfortable do you think you would be doing this on the imaginary team?
   - ☐ Uncomfortable doing this
   - ☐ Kind of uncomfortable doing this
   - ☐ Kind of comfortable doing this
   - ☐ Comfortable doing this

6) How likely or unlikely would you be to actually do this with the imaginary team?
   - ☐ Unlikely to do this
   - ☐ Kind of unlikely to do this
   - ☐ Kind of likely to do this
   - ☐ Likely to do this

Asking your teammates if they understand your idea.

7) How good or bad do you think you would be at doing this on the imaginary team?
☐ Bad at this
☐ Kind of bad at this
☐ Kind of good at this
☐ Good at this

8) How comfortable or uncomfortable do you think you would be doing this on the imaginary team?
☐ Uncomfortable doing this
☐ Kind of uncomfortable doing this
☐ Kind of comfortable doing this
☐ Comfortable doing this

9) How likely or unlikely would you be to actually do this with the imaginary team?
☐ Unlikely to do this
☐ Kind of unlikely to do this
☐ Kind of likely to do this
☐ Likely to do this

Encouraging your teammates to ask you questions about your idea to make sure they understand it correctly.[1]

10) How good or bad do you think you would be at doing this on the imaginary team?
☐ Bad at this
☐ Kind of bad at this
☐ Kind of good at this
☐ Good at this

11) How comfortable or uncomfortable do you think you would be doing this on the imaginary team?
☐ Uncomfortable doing this
☐ Kind of uncomfortable doing this
☐ Kind of comfortable doing this
☐ Comfortable doing this

12) How likely or unlikely would you be to actually do this with the imaginary team?
☐ Unlikely to do this
☐ Kind of unlikely to do this
☐ Kind of likely to do this
☐ Likely to do this

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[1] Item adapted from Johnson & Johnson (2013).

Sharing an idea even if you think your team might dislike it.

13) How good or bad do you think you would be at doing this on the imaginary team?
- ☐ Bad at this
- ☐ Kind of bad at this
- ☐ Kind of good at this
- ☐ Good at this

14) How comfortable or uncomfortable do you think you would be doing this on the imaginary team?
- ☐ Uncomfortable doing this
- ☐ Kind of uncomfortable doing this
- ☐ Kind of comfortable doing this
- ☐ Comfortable doing this

15) How likely or unlikely would you be to actually do this with the imaginary team?
- ☐ Unlikely to do this
- ☐ Kind of unlikely to do this
- ☐ Kind of likely to do this
- ☐ Likely to do this

Bringing up an idea for the [project/challenge] that is different from the idea the team just finished discussing.

16) How good or bad do you think you would be at doing this on the imaginary team?
- ☐ Bad at this
- ☐ Kind of bad at this
- ☐ Kind of good at this
- ☐ Good at this

17) How comfortable or uncomfortable do you think you would be doing this on the imaginary team?
- ☐ Uncomfortable doing this
- ☐ Kind of uncomfortable doing this
- ☐ Kind of comfortable doing this
- ☐ Comfortable doing this

18) How likely or unlikely would you be to actually do this with the imaginary team?
- ☐ Unlikely to do this
- ☐ Kind of unlikely to do this
- ☐ Kind of likely to do this
- ☐ Likely to do this

Now you are going to imagine that your teammates are sharing ideas with the imaginary team about the [project/challenge]. Remember, the imaginary team is you and two other people.
The next thing for you to think about doing on the imaginary team is:

Asking your teammate to explain their idea in a different way so you can understand it better.

19) How good or bad do you think you would be at doing this on the imaginary team?
☐ Bad at this
☐ Kind of bad at this
☐ Kind of good at this
☐ Good at this

20) How comfortable or uncomfortable do you think you would be doing this on the imaginary team?
☐ Uncomfortable doing this
☐ Kind of uncomfortable doing this
☐ Kind of comfortable doing this
☐ Comfortable doing this

21) How likely or unlikely would you be to actually do this with the imaginary team?
☐ Unlikely to do this
☐ Kind of unlikely to do this
☐ Kind of likely to do this
☐ Likely to do this

Asking your teammate to repeat their idea because you are unsure if you understood it correctly.[2]

22) How good or bad do you think you would be at doing this on the imaginary team?
☐ Bad at this
☐ Kind of bad at this
☐ Kind of good at this
☐ Good at this

23) How comfortable or uncomfortable do you think you would be doing this on the imaginary team?
☐ Uncomfortable doing this
☐ Kind of uncomfortable doing this
☐ Kind of comfortable doing this
☐ Comfortable doing this

24) How likely or unlikely would you be to actually do this with the imaginary team?
☐ Unlikely to do this
☐ Kind of unlikely to do this
☐ Kind of likely to do this
☐ Likely to do this

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[2] Item adapted from Johnson & Johnson (2013).

You are almost done! This next set of statements are about a variety of things that might happen while your imaginary team is working together on the [project/challenge]. Think about how easy or hard it would be for you to do what each statement says as part of this team.

How easy or hard would it be for you to do each of these things with the imaginary team?

	Hard to do this	Kind of hard to do this	Kind of easy to do this	Easy to do this
25) Listen closely to a teammate share an idea instead of focusing on what you are going to say to the team about your own idea.	☐	☐	☐	☐
26) Stay focused on the conversation your team is having instead of letting your mind wander.	☐	☐	☐	☐
27) Fully focus on what a teammate is saying instead of thinking about what you are going to say next to the team.	☐	☐	☐	☐
28) Stay focused on what a teammate is saying when you would rather be working on your part of the team [project/challenge].	☐	☐	☐	☐

APPENDIX B: HOW TO SCORE EACH OF THE FIVE FACTORS

Information Exchange Factor 1

Items related to youth sharing their information/idea with the team.

Sharing information you found about the topic of the [project/challenge] that none of your teammates have mentioned yet.

1) How good or bad do you think you would be at doing this on the imaginary team?	
Bad at this	Score = 1
Kind of bad at this	Score = 2
Kind of good at this	Score = 3
Good at this	Score = 4
2) How comfortable or uncomfortable do you think you would be doing this on the imaginary team?	
Uncomfortable doing this	Score = 1
Kind of uncomfortable doing this	Score = 2
Kind of comfortable doing this	Score = 3
Comfortable doing this	Score = 4
3) How likely or unlikely would you be to actually do this with the imaginary team?	
Unlikely to do this	Score = 1
Kind of unlikely to do this	Score = 2
Kind of likely to do this	Score = 3
Likely to do this	Score = 4

Explaining an idea you have to the team.

4) How good or bad do you think you would be at doing this on the imaginary team?	
Bad at this	Score = 1
Kind of bad at this	Score = 2
Kind of good at this	Score = 3
Good at this	Score = 4
5) How comfortable or uncomfortable do you think you would be doing this on the imaginary team?	
Uncomfortable doing this	Score = 1
Kind of uncomfortable doing this	Score = 2
Kind of comfortable doing this	Score = 3
Comfortable doing this	Score = 4
6) How likely or unlikely would you be to actually do this with the imaginary team?	
Unlikely to do this	Score = 1
Kind of unlikely to do this	Score = 2
Kind of likely to do this	Score = 3
Likely to do this	Score = 4

Information Exchange Factor 1 Score = <u>Sum of the scores across the six items</u>

6

Closed-Loop Communication Factor 2

Items related to youth's own idea.

Asking your teammates if they understand your idea.

7) How good or bad do you think you would be at doing this on the imaginary team?	
Bad at this	Score = 1
Kind of bad at this	Score = 2
Kind of good at this	Score = 3
Good at this	Score = 4
8) How comfortable or uncomfortable do you think you would be doing this on the imaginary team?	
Uncomfortable doing this	Score = 1
Kind of uncomfortable doing this	Score = 2
Kind of comfortable doing this	Score = 3
Comfortable doing this	Score = 4
9) How likely or unlikely would you be to actually do this with the imaginary team?	
Unlikely to do this	Score = 1
Kind of unlikely to do this	Score = 2
Kind of likely to do this	Score = 3
Likely to do this	Score = 4

Encouraging your teammates to ask you questions about your idea to make sure they understand it correctly.

10) How good or bad do you think you would be at doing this on the imaginary team?	
Bad at this	Score = 1
Kind of bad at this	Score = 2
Kind of good at this	Score = 3
Good at this	Score = 4
11) How comfortable or uncomfortable do you think you would be doing this on the imaginary team?	
Uncomfortable doing this	Score = 1
Kind of uncomfortable doing this	Score = 2
Kind of comfortable doing this	Score = 3
Comfortable doing this	Score = 4
12) How likely or unlikely would you be to actually do this with the imaginary team?	
Unlikely to do this	Score = 1
Kind of unlikely to do this	Score = 2
Kind of likely to do this	Score = 3
Likely to do this	Score = 4

Closed-loop Communication Factor 2 Score = <u>Sum of the scores across the six items</u>

6

Information Exchange Factor 2

Items related to bringing up an idea that might be more difficult to share

Sharing an idea even if you think your team might dislike it.

13) How good or bad do you think you would be at doing this on the imaginary team?	
Bad at this	Score = 1
Kind of bad at this	Score = 2
Kind of good at this	Score = 3
Good at this	Score = 4
14) How comfortable or uncomfortable do you think you would be doing this on the imaginary team?	
Uncomfortable doing this	Score = 1
Kind of uncomfortable doing this	Score = 2
Kind of comfortable doing this	Score = 3
Comfortable doing this	Score = 4
15) How likely or unlikely would you be to actually do this with the imaginary team?	
Unlikely to do this	Score = 1
Kind of unlikely to do this	Score = 2
Kind of likely to do this	Score = 3
Likely to do this	Score = 4

Bringing up an idea for the [project/challenge] that is different from the idea the team just finished discussing.

16) How good or bad do you think you would be at doing this on the imaginary team?	
Bad at this	Score = 1
Kind of bad at this	Score = 2
Kind of good at this	Score = 3
Good at this	Score = 4
17) How comfortable or uncomfortable do you think you would be doing this on the imaginary team?	
Uncomfortable doing this	Score = 1
Kind of uncomfortable doing this	Score = 2
Kind of comfortable doing this	Score = 3
Comfortable doing this	Score = 4
18) How likely or unlikely would you be to actually do this with the imaginary team?	
Unlikely to do this	Score = 1
Kind of unlikely to do this	Score = 2
Kind of likely to do this	Score = 3
Likely to do this	Score = 4

Information Exchange Factor 2 Score = $\dfrac{\text{Sum of the scores across the six items}}{6}$

Closed-Looped Communication Factor 1

Items related to a teammate's idea.

Asking your teammate to explain their idea in a different way so you can understand it better.

19) How good or bad do you think you would be at doing this on the imaginary team?	
Bad at this	Score = 1
Kind of bad at this	Score = 2
Kind of good at this	Score = 3
Good at this	Score = 4
20) How comfortable or uncomfortable do you think you would be doing this on the imaginary team?	
Uncomfortable doing this	Score = 1
Kind of uncomfortable doing this	Score = 2
Kind of comfortable doing this	Score = 3
Comfortable doing this	Score = 4
21) How likely or unlikely would you be to actually do this with the imaginary team?	
Unlikely to do this	Score = 1
Kind of unlikely to do this	Score = 2
Kind of likely to do this	Score = 3
Likely to do this	Score = 4

Asking your teammate to repeat their idea because you are unsure if you understood it correctly.

22) How good or bad do you think you would be at doing this on the imaginary team?	
Bad at this	Score = 1
Kind of bad at this	Score = 2
Kind of good at this	Score = 3
Good at this	Score = 4
23) How comfortable or uncomfortable do you think you would be doing this on the imaginary team?	
Uncomfortable doing this	Score = 1
Kind of uncomfortable doing this	Score = 2
Kind of comfortable doing this	Score = 3
Comfortable doing this	Score = 4
24) How likely or unlikely would you be to actually do this with the imaginary team?	
Unlikely to do this	Score = 1
Kind of unlikely to do this	Score = 2
Kind of likely to do this	Score = 3
Likely to do this	Score = 4

Closed-Loop Communication Factor 1 Score = <u>Sum of the scores across the six items</u>
<div align="center">6</div>

Listening Factor

How easy or hard would it be for you to do each of these things with the imaginary team?

25) Stay focused on what a teammate is saying when you would rather be working on your part of the team project.	
Hard to do this	Score = 1
Kind of hard to do this	Score = 2
Kind of easy to do this	Score = 3
Easy to do this	Score = 4
26) Listen closely to a teammate share an idea instead of focusing on what you are going to say to the team about your own idea.	
Hard to do this	Score = 1
Kind of hard to do this	Score = 2
Kind of easy to do this	Score = 3
Easy to do this	Score = 4
27) Fully focus on what a teammate is saying instead of thinking about what you are going to say next to the team.	
Hard to do this	Score = 1
Kind of hard to do this	Score = 2
Kind of easy to do this	Score = 3
Easy to do this	Score = 4
28) Stay focused on the conversation your team is having instead of letting your mind wander.	
Hard to do this	Score = 1
Kind of hard to do this	Score = 2
Kind of easy to do this	Score = 3
Easy to do this	Score = 4

Listening Factor Score = $\dfrac{\text{Sum of the scores across the four items}}{4}$

APPENDIX C: TECHNICAL DETAILS

The survey was developed and validity evidence was gathered through a rigorous four-phase development and validation process based on standards from the field of educational measurement (American Educational Research Association et al., 2014). Phase 1 focused on identifying and operationalizing the teamwork skill area to be measured by the survey. The skill area of team communication skills was most common among STEM OST programs and was defined as information exchange, closed-loop communication, and listening. In Phase 2, the survey scenario and items were developed and then reviewed by experts in STEM OST, youth development evaluation, teamwork, and measurement. Phase 3 involved think-aloud interviews and a national pilot test. Revisions to the survey occurred throughout each phase, leading to the final phase: a national field test of the survey. Through confirmatory factor analysis, a five-factor model of team communication skills was found to be a good fit. If you'd like to read a more detailed discussion about the development and validation of the Youth Teamwork Skills Survey, see Amy Grack Nelson's (2017) dissertation, "Development and validation of a survey to measure perceived team communication skills in middle and high school STEM out-of-school time programs." Contact Amy Grack Nelson at agnelson@smm.org to request a copy.

Overview of the Survey Development and Validation Process

Phase 1: Defining the Construct

- Literature review.
- In-depth interviews with 34 STEM OST practitioners.

Phase 2: Item Development and Expert Review

- Development of test blueprint and items.
- Expert review by 11 STEM OST practitioners.
- Revisions to items.
- Expert review by grant advisors in teamwork science, measurement, and youth development evaluation.
- Revisions to items.

Phase 3: Piloting and Revisions

- Iterative cycle of think-aloud interviews with 30 middle and high school youth and revisions to items.
- Pilot test with 310 middle and high school youth in 23 STEM OST programs.
- Conduct exploratory factor analysis, item analysis, descriptive statistics, and reliability.
- Revision and deletion of items.

Phase 4: Field Test

- Field test with 959 middle and high school youth in 40 STEM OST programs.
- Conduct confirmatory factor analysis, reliability, item analysis, descriptive statistics, and DIF analysis.
- Finalize instrument.

VALIDITY EVIDENCE

We gathered different types of construct validity evidence to be able to make the argument that the interpretation of scores on the survey are indeed a measure of someone's perception of their team communication skill level (based on the five skill areas of team communication skills). The validity argument includes construct validity evidence based on content, response process, and internal structure. This section provides a high-level overview of validity evidence for the survey. See Amy Grack Nelson's (2017) dissertation for more details about the psychometric tests and results.

Content–related validity evidence

Content-related validity evidence was gathered to look at the alignment of the survey items and scenario with the construct, or skill, areas of team communication skills. A first step was to review the literature and example items related to the construct while developing the survey to ensure that the construct of team communication skills was accurately represented. The STEM OST practitioners then provided feedback to ensure that the survey's scenario and items were relevant to the way teams are used in their programs, the team communication skills their programs address, and their evaluation needs. Many of the STEM OST practitioners said the scenario was similar to their program, but they had a number of suggested changes that were incorporated to better align the scenario with STEM OST team experiences.

Additional content validity evidence was gathered from the project's advisors. The advisors had expertise in measurement, teamwork science, and youth development evaluation. The advisors' feedback was important for gathering evidence related to the construct of team communication skills and the content (scenario and items) being used to measure the construct. The advisors provided feedback on the construct and the alignment of the individual items to the various skills areas (information exchange, closed-loop communication, and listening) within the construct. In some cases, this involved revision, removal, or addition of items to better ensure that a skill area was adequately covered by the items. At other times, an item may have been aligned with the wrong skill area and an advisor indicated what skill area it should be part of instead. The advisors also had suggestions about the scenario to make it more in alignment with key characteristics of teams. Additional content validity evidence was gathered from the teamwork science expert after the Phase 3 pilot test to ensure that the final items aligned with the team communication skill area they were intended to measure and the skill areas were adequately covered by the items. The expert felt that all of the items aligned with the skill areas. He noted that even though the scales were short, each of the items were a characteristic of the skill area of the team communication skills construct and he did not feel anything was missing.

Response process validity evidence

Response process validity evidence was gathered through think-aloud interviews to ensure that the way youth were interpreting the items aligned with the intention of what the item was meant to measure in relation to team communication skills (American Educational Research Association et al., 2014). A total of 30 middle and high school youth from 11 STEM OST programs were interviewed. Data from think-alouds helped to inform decisions on how to increase the validity and reliability of responses through scenario and item revisions. Items were revised to ensure they were being interpreted as intended, were easy to understand, were not culturally biased, and were clearly measuring the skill area of interest. In some cases, items were removed because they did not align with the skill areas they were meant to measure, meaning the items were not valid measures of the construct.

Internal structure validity evidence

Internal structure validity evidence came from exploratory factor analysis, confirmatory factor analysis and differential item functioning (DIF) analysis (American Educational Research Association et al., 2014).

The dimensionality of the construct was examined to understand if the construct of team communication skills was unidimensional or multidimensional. Exploratory factor analysis was carried out to understand how many factors, or dimensions, were measured by the items and if the items loaded well on the factor(s) (Brown, 2015). We conducted exploratory factor analysis for ordinal data using a polychoric correlation matrix, weighted least squares extraction method, and oblique rotation. A five-factor solution was chosen because it was most interpretable and made sense empirically and theoretically for the construct being measured.

Through confirmatory factor analysis, a five-factor model, with the addition of correlated errors between the good, comfort, and likely items for the closed-loop communication and information exchange anchor statements, was found to have good fit as suggested by the values for the fit indices (SRMR < .08, the RMSEA value and the 90% confidence interval less than .06, and CFI > .95). This provides evidence that the internal structure is five distinct factors related to the skill areas of team communication. This evidence of internal structure supports the use of individual factor scores for each of the five factors, instead of one total score for the survey.

Additional internal structure validity evidence was collected through differential item functioning (DIF) analysis using the Mantel-Haenszel procedure to look at item fairness for different groups of youth. DIF results were interpreted by looking at the significance of the Mantel-Haenszel χ^2 statistic and, when significant, computing the value of the ETS delta value (de Ayala, 2009; Zwick, 2012). When looking at gender, DIF was only slight to moderate in relation to favoring boys on one item. Three items had moderate to large (C) levels of DIF. In one case an item favored white youth over African-American/Black

youth, in a second case the item favored white youth over Asian youth, and in a third case the item favored Asian youth over white youth. However, when looking at a comparison of mean factor scores with and without the DIF items, there was not a statistically significant difference between focal and reference group means either with or without the DIF items included in the total factor score for the three items. Additionally, when accounting for multiple tests using the Bonferroni correction, none of the items were found to have DIF across the three groups of comparisons (Kim, 2010).

RELIABILITY

Reliability of responses was first addressed through the development and testing of the items and then checked statistically by computing coefficient alpha. An initial means to help avoid sources of measurement error was to develop items based on survey design guidelines and then test the items with potential audiences (Dillman, Smyth, & Christian, 2014). STEM OST practitioners first provided feedback on the items and scenario and brought to light any interpretation problems youth might experience. The survey was then tested with youth from the intended population to ensure that items were clearly interpreted and measuring what was intended. Any items where youth experienced confusion or had multiple interpretations were removed or reworded to help improve the reliability of survey responses. Reliability of responses for the field test data were calculated using coefficient alpha with parcels to account for the correlated errors in the model (Davenport et al., 2016). Both with and without parcels, each of the five factor scores were at or above $\alpha = .70$ (range without parcels $\alpha = .79$ to $\alpha = .88$, range with parcels $\alpha = .70$ to $\alpha = .79$), providing evidence of the reliability of the factor scores for the five factors (DeVellis, 2012).