IOWA

College of Education, Belin-Blank Center for Gifted Education & Talent Development

STEM Excellence & Leadership Quantitative Data Manual

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Aims of this Manual

STEM Excellence and Leadership is a prospective, longitudinal multiple cohort study of high-potential, rural, middle-school students in Iowa. The purpose of this document is to provide detailed information regarding the study design and, subsequently, guidelines to correctly prepare and analyze the data.

NSF Sponsored Research Overview

This $1.9 million NSF Advancing Informal Science Learning grant for *Implementing the STEM Excellence and Leadership Program to Understand the Role of Local Agency in broadening High-Potential, Rural Students' STEM Participation and Achievement* is a new Research is a Service to Practice project of the University of Iowa's (UI) Belin-Blank International Center for Gifted Education and Talent Development (B-BC). This project will examine the processes and learning outcomes related to the implementation of an after-school program, STEM Excellence and Leadership (*STEM Excellence*), in 10 rural Iowa middle schools.

The project goal is to advance the evidence-base around practices that optimally support the STEM achievement and efficacy of rural, high-potential students. The project has two objectives: 1) understand how informal STEM learning shapes the academic and psychosocial outcomes of rural, high-potential students, and 2) identify key characteristics of successful informal STEM learning environments for rural, high-potential students and their teachers. The project team will use a mixed methods approach, integrating comparative case study and mixed effects longitudinal methods, to study the Excellence program. Data sources include teacher interviews, classroom observations, and student assessments of academic aptitude and psychosocial outcomes. The analysis and evaluation of the program will be grounded in understanding the local efforts of school districts to build curriculum responsive to the demands of their high-potential student body. This project will provide significant insights in how best to design, implement, and support informal out-of-school learning environments to broaden participation in the highest levels of STEM education and careers for under-resourced rural students.

Intellectual Merit: *STEM Excellence* directly addresses the critical national need to measure and identify the attributes of out-of-school programs that work best for engaging under-resourced high-potential rural students in STEM. The proposed collaboration between the University of Iowa and rural school districts in Iowa will increase mutual understanding of the means through which young students can be more engaged in STEM. Through connecting talented rural, underserved students with opportunities to participate in the project's STEM activities, students will acquire the interest, confidence, and competency to pursue STEM at the highest levels. Finally, the means through which young students are provided with quality programming with academically accelerated experiences in STEM will help develop new models of intellectual engagement for some of most underserved students in the US.

Broader Impacts: Diversity in STEM is critical to innovation and the key to long-term economic growth and advancement in the US. This project will identify best practices for effective out-of-school STEM programming that identifies and develops STEM interest and talent early in high-potential, underserved rural youth. Over the four years of the project, *STEM Excellence* will expand understanding on how best to offer impactful STEM programming that broadens participation of members of underrepresented groups. The results of this project will be new tools for educators to increase the flow of underserved students into STEM.

STEM Excellence Program Overview

This program provides economically disadvantaged, rural students with informal STEM learning opportunities that place high-potential students on path for developing STEM expertise and qualifications for advanced STEM careers. *STEM Excellence and Leadership* (*STEM Excellence*) is operating in 10 rural Iowa middle schools. *Excellence* identifies rural high potential 5th graders (rising 6th graders) and provides intensive programming in mathematics and science during students' 6th-8th grade years, aiming to address the Excellence Gap (i.e., underrepresented students reach the highest levels of academic achievement at rates much lower than their majority peers). We are working to understand the specific barriers and affordances of *Excellence* that impact economically disadvantaged, high-potential, rural students' STEM achievement, aspirations, and preparation to navigate the educational pathways necessary for STEM academic and career success at the highest levels. *Excellence* schools:

- Cast a broad net to inclusively identify high-performing rising 6th grade students in math and science.
- Develop identified students' math and science abilities through 96 hours of extra-curricular academic programming (48 hours of math and 48 hours of science) each year for students during grades 6–8.
- Support students in attending academic residential summer programming (districts select students and help them apply and students receive scholarships though the grant).
- Attend professional development at the University of Iowa each summer.

COVID-19 Disruptions: Due to the impact of COVID-19 on schools, districts encountered a variety of barriers to implementation. One district began programming later in the academic year. One district moved to a fully online program through Brilliant.org where students worked asynchronously and independently. Another district met in-person with their students during the school day but held after-school programs online. There were a wide variety of responses to implementation during the pandemic, however schools were unable to conduct pre and post assessments, and program observations did not take place. Additionally, the project team restructured the summer 2021 professional development session from the traditional in person, on-campus experience to a virtual format. Throughout the year, professional development opportunities were made available through memberships to the National Council for Teachers of Mathematics (NCTM) and the National Science Teaching Association (NSTA).

STEM EXCELLENCE RESEARCH DESIGN

Setting & Participants

The *population* of this study included 10 rural school districts with approximately 1,000 students (all ten school combined) in grade 6. To participate in *STEM Excellence*, rural districts from a predominately rural Midwestern state applied to an open call. Selection of participating districts was based upon: (a) program commitment as exhibited through the application process, (b) location (implementation sites throughout state), and (c) free and reduced priced lunch (FRL) status. Eleven school districts were selected during the initial implementation of the program (AY2015-2016), with one dropping out at the end of the first year. By the last year of implementation (AY2020-2021), only eight schools continued their participation due to changes in school leadership, staffing shortages, and the COVID-19 pandemic.

From the study population, *participants* were selected through implementation of the Talent Development Model (Stanley, 2005) and application of an above-level testing program (Assouline & Lupkowski-Shoplik 2012). Specifically, teachers first nominated rising 6th grade students (in the spring of their 5th grade year) who scored at or above the 85th percentile on a grade-level standardized achievement test in math or science. This group of students represents the *talent pool* of rising 6th graders.

Next, nominated students completed a standardized above-level test and/or spatial reasoning assessment in the spring before their 6th grade year; those students who perform at locally-determined benchmarks were invited to participate in the program. Thus, the final *participants* in the *Excellence program* included students from the talent pool who were selected for participation by their district based on above-level testing scores.

Population	Talent Pool	Participants
Grade 6 students in 10 rural school districts (~1,000)	Rising 6th grade students who: • score at or above the 85th percentile on a standardized achievement test, or • are nominated by self, parent, or teacher and participate in the talent search (above-level testing)	Based on their above-level academic and/or spatial reasoning assessment, students from the talent pool are recommended to participate in the 3-year *Excellence* program (grades 6-8).

Data Sources

Data sources for this project are primarily quantitative and include the collection of students' achievement and psychosocial outcomes through established measures. All instruments were administered online in the Spring (April – May) of each year. The research team distributed the assessments to teachers who administered the surveys to their groups of students.

Student Achievement Outcomes

These outcomes are measured using one of three above-level tests: 1) ACT Explore, 2) I-Excel, and 3) ACT.

1. **ACT Explore:** used as a pre-test for rising 6th grade students (cohort 1) in 2015 to determine the talent pool. Explore uses a multiple-choice format with responses indicated on a machine-scored answer form. All tests and answer forms were scored by ACT. ACT (2013) reports that ACT Explore reliability coefficients and average standard errors of measurement (SEM) are weighted frequency distributions. Kuder-Richardson 20 (KR-20) internal consistency reliability coefficients for Form A, Grade 8 ACT Explore scale scores are English, 0.84 (SEM = 1.66); Math, 0.76 (SEM = 1.71); Reading, 0.86 (SEM = 1.44); and Science, 0.79 (SEM = 1.53). ACT discontinued the use of Explore in 2016.

2. **I-Excel:** switched to I-Excel in Spring 2016 due to discontinued Explore. I-Excel was used as a pre-test measure for rising 6th grade students and a post-test at the end of Grade 6. I-Excel is an online test of 8th grade content licensed from ACT (2013) and administered as an above-level test to high-potential 4th –6th graders. Like Explore, I-Excel includes four tests: English (40 items), Math (30 items), Reading (30 items), and Science (28 items). Raw scores are converted to a scale score; scale score ranges are 1–25.

3. **ACT:** used as above-level test as participants entered 7th and 8th grade. ACT also consists of four multiple-choice tests: English, Mathematics, Reading, and Science. Scales scores are used in analyses.

The use of these assessments has been established in the literature on above-level standardized tests and the talent search model (Assouline et al., 2015; Rogers, 2015).

Student Psychosocial Outcomes

Psychosocial outcomes were measured primarily using two instruments: 1) ACT-Engage (2015-2016, 2016-2017), and 2) Patterns of Adaptive Learning (2017-2021).

1. For the **pilot implementation**, students completed the **ACT-Engage** assessments. Students responded to items that have been factored into 10 areas, which correspond to three broad psychosocial domains: motivation, social-engagement, and self-regulation (ACT, 2009). Scores are reported as percentiles and are compared to the 6th –9th grade norms.

2. For the **NSF-funded implementation**, students filled out the **Patterns of Adaptive Learning Survey** (PALS), which uses a five-point Likert scale to measure students on their perceptions of the following: their mastery and performance goal orientation; their achievement-related beliefs, attitudes and strategies; program leader's goals; program goals; and extrinsic factors, such as parents' expectations (Midgely et al., 2000, p. 2). The survey also explores the extent which students engage in (i.e., performance-approach) or avoid (i.e., performance-avoid) challenge during learning opportunities, especially when comparing themselves to their peers. (Midgley et al., 2000). The PALS measure was originally validated on middle school students (Midgely et al., 2000) and has been used to explore the goal orientation of middle school students in general, as well as specifically in math and science (Anderman, 1999; Gilbert et al., 2014; Middleton & Midgely, 2002; Tyler, 2002) making it an appropriate measure by which to explore the mastery and performance learning goals of the program participants. Descriptions of the subscales are detailed below.

Personal Achievement Goal Orientation Scales

The Revised Personal Achievement Goal Orientations Scale (Midgley et al., 2000) measures middle school students' motivational reasons for engaging in competence-based activities, which have been termed achievement goals (Dweck, 1986). The achievement goals subscales include mastery goal orientation, performance-approach goal orientation, and performance-avoidance goal orientation. Sample items include, "It's important to me that I learn a lot of new concepts this year" for mastery, "It's important to me that other students in my class think I am good at my class work" for performance-approach, and "One of my goals is to keep others from thinking I'm not smart in class" for performance-avoid. Each subscale contains five items and is rated on a 5-point scale ranging from 1 (Not True at All) to 5 (Very True) with higher scores reflecting greater adherence to that goal orientation. In the original study, the revised subscales achieved a Cronbach's alpha coefficient of 0.85, 0.89, and 0.74, respectively.

Perception of Classroom goal Structures scales (Midgley et al., 2000)

Classroom Mastery Goal Structure: measures middle school students' perception that the purpose of engaging in classwork is to increase their competence. Sample items include, "In our class, it's important to understand the work, not just memorize it" and "In our class, learning new ideas and concepts is very important." The 6-item scale is rated on a 5-point scale ranging from 1 (Not True at All) to 5 (Very True) with higher scores reflecting a greater belief that schoolwork is meant to increase competence. The scale achieved a Cronbach's alpha coefficient of 0.76 in the original study.

Classroom Performance-Approach Goal Structure: measures middle school students' perception that the purpose of engaging in classwork is to demonstrate their competence. Sample items include, "In our class, it's important to get high scores on tests" and "In our class, getting good grades is the main goal." The 3-item scale is rated on a 5-point scale ranging from 1 (Not True at All) to 5 (Very True) with higher scores reflecting greater belief that schoolwork is meant to demonstrate competence. The scale achieved a Cronbach's alpha coefficient of 0.70 in the original study.

Classroom Performance-Avoid Goal Structure: measures middle school students' perception that the purpose of engaging in classwork is to avoid a demonstration of incompetence. Sample items include, "In our class, showing others that you are not bad at class work is really important" and "In our class, it's important not to do worse than other students." The 5-item scale is rated on a 5-point scale ranging from 1 (Not True at All) to 5 (Very True) with higher scores reflecting greater belief that the purpose of classwork is to not demonstrate incompetence. The scale achieved a Cronbach's alpha coefficient of 0.83 in the original study.

Overall Perception of Classroom Goal Structure: measures middle school students' perception of the purpose of engaging in classwork. The three subscales include classroom mastery goal structure (6-items), classroom performance-approach goal structure (3-items), and classroom performance-avoid goal structure (5-items). Sample items include, "In our class, it's important to understand the work, not just memorize it" for mastery, "In our class, getting good grades is the main goal" for performance-approach, and "In our class, it's important not to do worse than other students" for performance-avoid. Each subscale is rated on a 5-point scale ranging from 1 (Not True at All) to 5 (Very True) with higher subscale scores reflecting greater belief in that subscale goal orientation. The classroom mastery, performance-approach, and performance-avoid subscales achieved a Cronbach's alpha coefficient of 0.76, 0.70, and 0.83 respectively.

Academic-Related Perceptions, Beliefs, and Strategies scales (Midgley et al., 2000)

Academic Efficacy: measures middle school students' perception of their competency to complete classwork. Sample items include, "I can do even the hardest work in class if I try" and "I can do almost all the work in class if I don't give up." The 5-item scale is rated on a 5-point scale ranging from 1 (Not True at All) to 5 (Very True) with higher scores reflecting greater belief in their competency to complete classwork. The scale achieved a Cronbach's alpha coefficient of 0.78 in the original study.

Academic Press: measures middle school students' perception of being pressed by teachers for understanding. Sample items include, "My teacher accepts nothing less than my full effort" and "My teacher makes sure that the work I do really makes me think." The 7-item scale is rated on a 5-point scale ranging from 1 (Not True at All) to 5 (Very True) with higher scores reflecting greater belief that they are pressed by teachers for understanding. The scale achieved a Cronbach's alpha coefficient of 0.79 in the original study.

Academic Self-Handicapping Strategies: measures middle school students' strategies for attributing subsequent low performance to the circumstances surrounding the performance rather than attributing low performance to their lack of ability. Sample items include, "Some students fool around the night before a test. Then if they don't do well, they can say that is the reason. How true is this for you?" and "Some students purposely don't try hard in class. Then if they don't do well, they can say it is because they didn't try. How true is this of you?" The 6-item scale is rated on a 5-point scale ranging from 1 (Not True at All) to 5 (Very True) with higher scores reflecting greater attribution of low performance to circumstances rather than lack of ability. The scale achieved a Cronbach's alpha coefficient of 0.84 in the original study.

Self-Presentation of Low Achievement: measures middle school students' preference to have peers be unaware of their high achievement in school. Sample items include, "If I were good a my class work, I would try to do my work in a way that didn't show it" and "One of my goals in class is to avoid looking smarter than other kids." The 6-item scale is rated on a 5-point scale ranging from 1 (Not True at All) to 5 (Very True) with higher scores reflecting greater preference to not be known as a high achiever in school by peers. The self-presentation of low achievement scale achieved a Cronbach's alpha coefficient of 0.78 in the original study.

Skepticism About the Relevance of School for Future Success: measures middle school students' belief that doing well in school will not benefit their ability to achieve in the future. Sample items include, "Even if I am successful in school, it won't help me fulfill my dreams" and "Doing well in school doesn't improve my chances of having a good life when I grow up." The 6-item scale is rated on a 5-point scale ranging from 1 (Not True at All) to 5 (Very True) with higher scores reflecting greater belief that doing well in school will not help them achieve future success. The scale achieved a Cronbach's alpha coefficient of 0.83 in the original study.

We also collected two other theory-based scales.

Academic Attribution Scale: The Academic Attribution Scale (Assouline et al., 2006) measures the degree to which K-12 students attribute their success or failure in subject specific classes to controllable versus uncontrollable causes, as well as ability versus effort causes. The 6-point scale, adapted from the original scale by Pintrich and Schunk (1996), measures the success and failure attributions for subject specific classes by investigating whether students attribute their success or failure in a given class to their intelligence, their long-term effort, the ease of the task, their luck, how a teacher feels about them, or their situational effort. For success attribution, students are asked if they do well in a class because (1) I am smart, (2) I work hard, (3) the work is easy, (4) I am lucky, (5) my teachers like me, and (6) I do my work the right way. For failure attribution, students are asked if they don't do well in a class because (1) I am not smart enough, (2) I don't work hard enough, (3) the work is hard, (4) I have bad luck, (5) my teachers don't like me, and (6) I don't do my work the right way.

Math/Science Career Self-Efficacy Scale: The Math/Science Career Self-Efficacy Scale (Fouad et al., 1997; Smith & Fouad, 1999) measures middle school students' self-efficacy, outcome expectancy, and intentions and goals in career decision making in math and science. The scale was developed and validated to assess specific propositions of the Social Cognitive Model as it pertains to math/science vocational interests of ethnically diverse middle school students (Fouad & Smith, 1996). The scale includes four subscales:

Math/Science Self-Efficacy: measures middle school students' perception that they have the ability to succeed in math and science. Sample items included, "I think I can earn an 'A' in math in high school" and "I think I can design and describe a science experience that I want to do." The scale was measured on a 5-point Likert scale ranging from 1 (very low ability) to 5 (very high ability) with high scores reflecting greater belief in their ability to succeed in math and science. A total score is calculated by taking the sum of 12 items. The Cronbach's alpha for the total score in the original study was 0.84; Cronbach's alpha for math only (5 items) was 0.70 and for science only (7 items) was 0.79.

Math/Science Outcome Expectancies/Intentions-Goals: measures middle school students' intention to pursue career goals related to math and science and their belief that activities in math and science will increase their potential achievement in the future. Sample items include "If I learn math well, then I will be able to do lots of different types of careers" and "I am determined to use my science knowledge in my future career." The scale was measured on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) with high scores reflecting greater belief in their ability to succeed in math and science. A total score is calculated by taking the sum of 6 items. The Cronbach's alpha for the total score in the original study was 0.80; Cronbach's alpha for math only (4 items) was 0.76 and for science only (2 items) was 0.62.

Middle School Career Decision-Making Self-Efficacy: measures middle school students' ability to engage in the career decision-making process. Sample items include "Make a plan of my education goals for the next three years" and "Choose a career that will fit my interests." The scale was measured on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) with high scores reflecting greater belief in their ability to complete the relevant activities. A total score is calculated by taking the sum of 12 items. The Cronbach's alpha for the total score in the original study was 0.79.

Middle School Career Decision-Making Expectancies/Intentions-Goals: measures middle school students' intention to partake in career decision-making processes and their belief that doing those activities will help them make better career decisions. Sample items include "I intend to spend more time learning about career opportunities" and "If I make a good career decision, then my parents will approve of me." The scale was measured on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) with high scores reflecting greater belief in their ability to complete the relevant activities. A total score was calculated separately for outcome expectancies (5 items, alpha = 0.70) and intentions/goals (5 items, alpha 0.74).

Data Analysis Considerations

The research design allows for the examination of multiple hypotheses regarding the effects of *STEM Excellence*. Specifically, we have cross-sectional and longitudinal data with which to compare post-treatment gains with pre-treatment growth rates, thereby addressing alternative explanations for posttest gains because of students' natural maturation.

Analytical Study Cohorts

The table on page 12 summarizes the study cohorts with information about the sample sizes for total enrollment, consent, and valid outcome data.

Enrollment

Enrollment sample size includes any student who was identified for the talent pool and invited to participate in the STEM Excellence program in their 6th grade year [see **STEM Excellence Program Overview** (p.4) for information about the intervention protocol]. During their participation in the study, students completed surveys as part of the program.

Additional steps were conducted to request access to the survey data for research purposes. Participation in the research study (i.e., agreeing to give access to the data for research) was completely voluntary and did not impact participation in the STEM Excellence program nor involve additional time outside of program activities.

In the description of **Analytical Study Cohorts,** the sample size for enrollment for each cohort is denoted by $\mathbf{n_t}$.

Consent

Parental consent and child assent were collected from study participants after students were identified for the talent pool. A link to the Consent/Assent document was included in the confirmation e-mail parents received when they registered their child for above-level testing.

During Spring 2020, due to modification to the study protocol (i.e., additional data requests and adjustments due to COVID-19), consent was requested again from ALL participants who were enrolled in the program. Thus, students in Cohorts 1-4 consented a second time, while Cohorts 5-6 consented for the first time. If a student had more than one response to consent (especially if it was conflicting), we counted the 2020 consent as their final decision. The overall consent rate for the project was 53.14%.

In the description of the **Analytical Study Cohorts,** the sample size for consent for each cohort is denoted by n_c. The consent rate = $[n_c / n_t] \times 100$

Attrition & Nonresponse

Loss of participants in both the STEM Excellence program and research was anticipated given the longitudinal nature of the project.

We consider **attrition** as those participants who dropped out of the program. Attrition was most frequently attributed to students moving out of the school/district or students' scheduling conflicts with other extracurricular activities. We had school-level attrition (3 schools total) due to changes in school administration support for the program and staffing shortages.

We consider **nonresponse** as those participants who participated in the program but: 1) did not provide consent for research participation and 2) had missing survey data.

In the description of the **Analytical Study Cohorts,** the sample size for valid consent and outcome data for each cohort is denoted by n_r. Nonresponse is based on time 1. Nonresponse rate = $[(n_t - n_r)/ n_t] \times 100$

Table 1. *Number of students in each cohort who enrolled, consented, and had valid outcome data.*

	Time Period	n_t	n_c	n_r (achievement)	n_r (psychosocial)
Cohort 1	2015-2018	178	65	56	54
Cohort 2	2016-2019	172	86	74	6
Cohort 3	2017-2020	164	130	135	104
Cohort 4	2018-2021	146	125	176	9
Cohort 5	2019-2021	102	95	143	34
Cohort 6	2020-2021	79	60	0	0
	Total	841	561	584	207

Note: n_t = total enrolled, n_c = total consent, n_r = total with outcome data.

Analysis Data Files

Academic Achievement

Achievement Outcomes-ALL cohorts (De-Identified) → excel file

(wide data format)

Includes the following variables:

Variable	Label	Description
caseid	Case ID	Student's Case ID
cohort	Cohort	Student's Cohort
eng_exp15	Explore 2015 English Score	Cohort 1 students' pre-test
math_exp15	Explore 2015 Math Score	Cohort 1 students' pre-test
read_exp15	Explore 2015 Reading Score	Cohort 1 students' pre-test
science_exp15	Explore 2015 Science Score	Cohort 1 students' pre-test
comp_exp15	Explore 2015 Composite Score	Cohort 1 students' pre-test
eng_exp16	Explore/I-Excel 2016 English Score	Cohort 1 students' Explore post-test and Cohort 2 students' I-Excel pre-test
math_exp16	Explore/I-Excel 2016 Math Score	Cohort 1 students' Explore post-test and Cohort 2 students' I-Excel pre-test
read_exp16	Explore/I-Excel 2016 Reading Score	Cohort 1 students' Explore post-test and Cohort 2 students' I-Excel pre-test
science_exp16	Explore/I-Excel 2015 Science Score	Cohort 1 students' Explore post-test and Cohort 2 students' I-Excel pre-test
comp_exp16	Explore 2015 Composite Score	Cohort 1 students' Explore post-test
eng_iex17	I-Excel 2017 English Score	Cohort 2 students' post-test and cohort 3 students' pre-test
math_iex17	I-Excel 2017 Math Score	Cohort 2 students' post-test and cohort 3 students' pre-test
read_iex17	I-Excel 2017 Reading Score	Cohort 2 students' post-test and cohort 3 students' pre-test
science_iex17	I-Excel 2017 Science Score	Cohort 2 students' post-test and cohort 3 students' pre-test
eng_iex18	I-Excel 2018 English Score	Cohort 3 students' post-test and cohort 4 students' pre-test
math_iex18	I-Excel 2018 Math Score	Cohort 3 students' post-test and cohort 4 students' pre-test
read_iex18	I-Excel 2018 Reading Score	Cohort 3 students' post-test and cohort 4 students' pre-test
science_iex18	I-Excel 2018 Science Score	Cohort 3 students' post-test and cohort 4 students' pre-test
eng_iex19	I-Excel 2019 English Score	Cohort 4 students' post-test and cohort 5 students' pre-test
math_iex19	I-Excel 2019 Math Score	Cohort 4 students' post-test and cohort 5 students' pre-test
read_iex19	I-Excel 2019 Reading Score	Cohort 4 students' post-test and cohort 5 students' pre-test
science_iex19	I-Excel 2019 Science Score	Cohort 4 students' post-test and cohort 5 students' pre-test
eng_act17	ACT 2017 English Score	Cohort 1 students' post-test
math_act17	ACT 2017 Math Score	Cohort 1 students' post-test
read_act17	ACT 2017 Reading Score	Cohort 1 students' post-test
science_act17	ACT 2017 Science Score	Cohort 1 students' post-test
comp_act17	ACT 2017 Composite Score	Cohort 1 students' post-test
eng_act18	ACT 2018 English Score	Cohort 1 and 2 students' post-test
math_act18	ACT 2018 Math Score	Cohort 1 and 2 students' post-test
read_act18	ACT 2018 Reading Score	Cohort 1 and 2 students' post-test
science_act18	ACT 2018 Science Score	Cohort 1 and 2 students' post-test
comp_act18	ACT 2018 Composite Score	Cohort 1 and 2 students' post-test
eng_act19	ACT 2019 English Score	Cohort 2 and 3 students' post-test
math_act19	ACT 2019 Math Score	Cohort 2 and 3 students' post-test
read_act19	ACT 2019 Reading Score	Cohort 2 and 3 students' post-test
science_act19	ACT 2019 Science Score	Cohort 2 and 3 students' post-test
comp_act19	ACT 2019 Composite Score	Cohort 2 and 3 students' post-test

Psychosocial Outcomes

Psychosocial Outcomes-ALL cohorts (De-Identified) → excel file

(long/stacked data format)

Variable Name	Description
Case ID	Student's Case ID
cohort	Student's Cohort
survey participation	Indicator variable for survey administration timepoint (repeated measure)
time	Indicator variable for data collection timepoint (repeated measure)
year	Year of data collection: 2015, 2016, 2017, 2018, 2019, 2020, 2021
survey	Indicator variable for psychosocial scale: Engage, PALS
Prior grades	Engage subscale
Academic Success Index Percentile	Engage subscale
Graduation Index Percentile	Engage subscale
Academic Discipline Percentile	Engage subscale
Commitment to School Percentile	Engage subscale
Family Attitude toward Education Percentile	Engage subscale
Family Involvement Percentile	Engage subscale
Managing Feelings Percentile	Engage subscale
Optimism Percentile	Engage subscale
Orderly Conduct Percentile	Engage subscale
Relationships with School Personnel Percentile	Engage subscale
School Safety Climate Percentile	Engage subscale
Thinking Before Acting Percentile	Engage subscale
Changed Schools	Engage subscale
Without Homework	Engage subscale
Homework (Hours per Day)	Engage subscale
TV (Hours per Day)	Engage subscale
Video Games (Hours per Day)	Engage subscale
Internet (Hours per Day)	Engage subscale
Skipped Class	Engage subscale
Days Absent (Past Month)	Engage subscale
Days Late (Past Month)	Engage subscale
Response Inconsistency Flag	Engage subscale
Scoring Flag Notes	Engage subscale
Academic Success Index Probability	Engage subscale
Graduation Index Probability	Engage subscale

Academic Discipline	Engage subscale
Commitment to School Score	Engage subscale
Family Attitude toward Education Score	Engage subscale
Family Involvement Score	Engage subscale
Managing Feelings Score	Engage subscale
Optimism Score	Engage subscale
Orderly Conduct Score	Engage subscale
Relationships with School Personnel Score	Engage subscale
School Safety Climate Score	Engage subscale
Thinking Before Acting Score	Engage subscale
par_year	I have been in the STEM Excellence and Leadership program for _____ years.
pro_proud	I am proud to participate in the program.
pro_satisfy	I feel a sense of satisfaction from studying in the program.
pro_bore	I am bored in my regular classes.
pro_challenge	I enjoy the challenge of learning in the program.
pro_others	I enjoy studying with the other students in the program more than in my regular class.
pro_reward	I find participating in the program rewarding.
pro_creativity	In the program my creativity is supported.
pro_ability	In the program my abilities to think critically are supported.
pro_attention	In the program my teachers give me personal attention.
pro_academic	Being in the program helps me deal with academic challenges.
pro_beyond1	Because of the program I want to seek information beyond what we study in class.
new_math	I experienced new ways of learning math in the program.
pro_beyond2	Because of the program I want to seek information beyond what we study in class.
dep_math	I want to study math in more depth because of this program.
curi_math	I became curious about different math ideas because of this program.
chal_math	I feel that the math I learn in this program is challenging.
comb_math	The math material is a good combination of information and investigations.
enjoy_math	I enjoy the math activities in the program.
change_math	The math activities in the program should be changed.
reg_math	The math lessons in my regular class are too easy for me.
compare_math	The program math teacher teaches in a more interesting and stimulating way than in my regular math class.
think_math	Because of the program I think about math in my free time.
new_sci	I experienced new ways of learning science in the program.
dep_sci	I want to study science in more depth because of the program.
curi_sci	I became curious about different science ideas because of this program.
chal_sci	I feel that the science I learn in this program is challenging.

comb_sci	The science material is a good combination of information and investigations.
enjoy_sci	I enjoy the science activities in the program.
change_sci	The science activities in the program should be changed.
reg_sci	The science lessons in my regular class are too easy for me.
compare_sci	The program science teacher teaches in a more interesting and stimulating way than in my regular math class.
think_sci	Because of the program I think about science in my free time.
inter_sci	I attended the program because I was interested in science.
inter_math	I attended the program because I was interested in math.
att_parent	I attended the program because my parents wanted me to.
att_teacher	I attended the program because my teacher(s) wanted me to.
pro_next	If possible, I will attend the program next year.
pro_topic	What lessons or topics interest you most in the STEM Excellence and Leadership program this school year?
pro_compare	In what ways are the lessons in the STEM Excellence and Leadership program different from the lessons in your regular math or science classes?
idea	What else do you want us to know?
workwell	When I do well on my school work, it is usually because...
wellmath	When I do well in mathematics, it is usually because...
wellart	When I do well in language arts, it is usually because...
wellsci	When I do well in science, it is usually because...
workbad	When I DON'T do well on my school work, it is usually because...
badmath	When I DON'T do well in mathematics, it is usually because...
badart	When I DON'T do well in language arts, it is usually because...
badsci	When I DON'T do well in science, it is usually because...
wellschool	When you do well in school, it is usually because:
chalschool	When school is challenging, you are more likely to:
assist	When you need to ask for assistance, are you more likely to seek it from:
seekhelp	From whom are you likely to seek assistance?
feel_math	When I am in a math setting, I feel:
feel_sci	When I am in a science setting, I feel:
feel_art	When I am in a language arts setting, I feel:
girls_school	When comparing yourself with girls in your grade, how good are you in school
girls_math	When comparing yourself with girls in your grade, how good are you in math
girls_art	When comparing yourself with girls in your grade, how good are you in art
girls_sci	When comparing yourself with girls in your grade, how good are you in science
boys_school	When comparing yourself with boys in your grade, how good are you in school
boys_math	When comparing yourself with boys in your grade, how good are you in math

boys_art	When comparing yourself with boys in your grade, how good are you in art
boys_sci	When comparing yourself with boys in your grade, how good are you in science
efficacy_masterskills	Academic Efficacy
selfpresent_avoid	Self-Presentation of Low Achievement
perav_stupid	Performance-Avoid Goal Orientation (Revised)
skept_nohelp	Skepticism About the Relevance of School for Future Success
selfpresent_luck	Self-Presentation of Low Achievement
press_challenge	Academic Press
perap_others	Performance-Approach Goal Orientation (Revised)
master_concept	Mastery Goal Orientation (Revised)
press_teacher	Academic Press
efficacy_diffwork	Academic Efficacy
selfhandi_fool	Academic Self-Handicapping Strategies
skept_latersuccess	Skepticism About the Relevance of School for Future Success
press_explain	Academic Press
selfhandi_activities	Academic Self-Handicapping Strategies
press_keepthinking	Academic Press
selfhandi_notstudy	Academic Self-Handicapping Strategies
press_easywork	Academic Press
selfpresent_volunteer	Self-Presentation of Low Achievement
selfpresent_grade	Self-Presentation of Low Achievement
master_learn	Mastery Goal Orientation (Revised)
perap_showgood	Performance-Approach Goal Orientation (Revised)
selfpresent_smarter	Self-Presentation of Low Achievement
skept_goodlife	Skepticism About the Relevance of School for Future Success
master_skill	Mastery Goal Orientation (Revised)
skept_grade	Skepticism About the Relevance of School for Future Success
perav_smart	Performance-Avoid Goal Orientation (Revised)
skept_dream	Skepticism About the Relevance of School for Future Success
selfpresent_show	Self-Presentation of Low Achievement
master_understand	Mastery Goal Orientation (Revised)
perap_showeasy	Performance-Approach Goal Orientation (Revised)
selfhandi_friends	Academic Self-Handicapping Strategies
skept_career	Skepticism About the Relevance of School for Future Success
selfhandi_nottry	Academic Self-Handicapping Strategies
perap_smart	Performance-Approach Goal Orientation (Revised)
selfpresent_avoidsmart	Self-Presentation of Low Achievement

selfhandi_putoff	Academic Self-Handicapping Strategies
perap_looksmart	Performance-Approach Goal Orientation (Revised)
master_improve	Mastery Goal Orientation (Revised)
perav_knowless	Performance-Avoid Goal Orientation (Revised)
efficacy_giveup	Academic Efficacy
press_think	Academic Press
perav_trouble	Performance-Avoid Goal Orientation (Revised)
efficacy_hardwork	Academic Efficacy
press_fulleffort	Academic Press
efficacy_hardest	Academic Efficacy
classmastery_hardwork	Classroom Mastery Goal Structure
classperavoid_show	Classroom Performance-Avoid Goal Structure
classmastery_improve	Classroom Mastery Goal Structure
classperapp_grade	Classroom Performance-Approach Goal Structure
classmastery_understand	Classroom Mastery Goal Structure
classperapp_answer	Classroom Performance-Approach Goal Structure
classperavoid_mistake	Classroom Performance-Avoid Goal Structure
classmastery_notmemo	Classroom Mastery Goal Structure
classperavoid_worse	Classroom Performance-Avoid Goal Structure
classmastery_new	Classroom Mastery Goal Structure
classperavoid_dumb	Classroom Performance-Avoid Goal Structure
classmastery_mistake	Classroom Mastery Goal Structure
classperapp_scores	Classroom Performance-Approach Goal Structure
classperavoid_look	Classroom Performance-Avoid Goal Structure
can_library	Find information in the library about five occupations I am interested in.
can_plan	Make a plan of my education goals for the next three years.
can_select	Select one occupation from a list of possible occupations I am considering.
can_deter	Determine what occupation would be best for me.
can_value	Decide what I value most in an occupation.
can_resist	Resist attempts of parents or friends to push me into a career I believe is beyond my abilities or not for me.
can_desc	Describe the job skills of a career I might like to enter.
can_opp	Choose a career in which most workers are the opposite sex.
can_fit	Choose a career that will fit my interests.
can_school	Decide what kind of schooling I will need to achieve my career goal.
can_salary	Find out the average salary of people in an occupation.
can_talk	Talk with a person already employed in a field I am interested in.
career_dec	If I learn more about different careers, I will make a better career decision.

career_abil	If I know my interests and abilities, then I will be able to choose a good career for me.
parent_appr	If I make a good decision, then my parents will approve of me.
career_ed	If I know about the education I need for different careers, I will make a better career decision.
career_info	If I spend enough time gathering information about careers, I can learn what I need to know when I make a decision.
career_time	I intend to spend more time learning about careers than I have been.
career_talk	I plan to talk to lots of people about careers.
career_opp	I am determined to talk to my teachers about career opportunities.
career_learn	I am committed to learning more about my abilities and interests.
career_edu	I intend to get all the education I need for my career choice.
career1	I intend to be:
career2	If not that, then:
career3	If not that, then:
ab_math	Earn an ’A’ in math.
ab_mathhs	Earn an ’A’ in science.
ab_tax	Get an ’A’ in math in high school.
ab_spend	Get an ’A’ in science in high school.
ab_mile	Determine the amount of sales tax on the clothes I want to buy.
ab_rain	Collect dues to determine how much to spend for a school club.
ab_sci	Figure out how long it will take to travel from Milwaukee to Madison, driving at 55 mph.
ab_scihs	Design and describe a science experiment that I want to do.
ab_design	Classify animals that I observe.
ab_anim	Predict weather from weather maps.
ab_weather	Construct and interpret a graph of rainfall amounts by state.
ab_hyp	Develop a hypothesis about why kids watch a particular show.
math_goal	If I take lots of math courses, then I will be better able to achieve my future goals.
math_career	If I learn math well, then I will be able to do lots of different types of careers.
math_grade	If I take a math course, then I will increase my grade point average.
math_parent	If I do well in science classes in middle school, then I will do well in high school.
math_adv	If I get good grades in math, then my parents will be pleased.
math_job	If I do well in science, then I will better prepared to go to college.
sci_hs	I plan to take the highest available math course my high school offers.
sci_college	I intend to take the highest available science course my high school offers.
sci_adv	I am committed to study hard in my science classes.
sci_study	I intend to enter a career that will use math.
sci_career	I am determined to use my science knowledge in my future career.

sci_job	I intend to enter a career that will use science.
career_parent	The career my parents want for me is:
career_teacher	The career my teachers think I should enter is:
covid	Indicator variable for COVID-19
efficacy	PALS Academic Efficacy composite
press	PALS Academic Press composite
selfhandi	PALS Self-Handicapping Strategies composite
classmastery	PALS Classroom Mastery Goal Structure composite
classperapp	PALS Classroom Performance-Approach Goal Structure composite
classperavoid	PALS Classroom Performance-Avoid Goal Structure composite
master	PALS Personal Mastery composite
perap	PALS Personal Performance-Approach composite
perav	PALS Personal Performance-Avoid composite
selfpresent	PALS Self-Presentation of Low Achievement composite
skept	PALS Skepticism composite

Types of Analyses

Cross-Sectional Analyses

Capture differences between grades at the same data point (**cohort x year**)

Capture difference between cohorts in the same grade (**cohort x grade**)

Longitudinal Analyses

Capture growth/trends within cohorts across data points (**cohort x time**)

Table 2. *Summary of STEM Excellence implementation by cohort, academic year, and grade.*

	Pilot Implementation[A]		**NSF-Funded Implementation[B]**				
	2015-2016	**2016-2017**	**2017-2018**	**2018-2019**	**2019-2020**	**2020-2021**	
Cohort 1	6th	7th	8th				**Longitudinal**
Cohort 2		6th	7th	8th			
Cohort 3			6th	7th	8th		
Cohort 4				6th	7th	8th	
Cohort 5					6th	7th	
Cohort 6						6th	
	Cross-Sectional						

[A] Data sources: Explore, Engage.

[B] Data sources: I-Excel, ACT, PALS, Attribution, Math/Science Career Self-Efficacy.

IOWA

College of Education, Belin-Blank Center for Gifted Education & Talent Development

STEM Excellence & Leadership Qualitative Data Manual

TABLE OF CONTENTS

Aims of this Manual

The Qualitative Data manual serves as a companion to the Quantitative Data Manual published for the *STEM Excellence and Leadership* longitudinal survey study. As with the Quantitative Manual, it is important to strive for utmost accuracy and transparency when disseminating information about our process and findings. It should be readily apparent from our findings and discussion exactly what we did, how we did it, and how we reached the decisions that led to our findings and implementation. This manual serves as a how-to guide that informs the qualitative data analysis that we conducted for *STEM Excellence and Leadership*. It also serves as a description of the data that inform the disseminated findings from *STEM Excellence and Leadership.*

Important considerations to keep in mind at all times are: If I were to replicate this study, what would I need to know in order to do so? How can I create a roadmap for future research that builds upon my study? What would I need to see if I were building upon someone else's study?

The questions above inform this guidebook.

Grant Requirements

Data Produced in the Course of the Project

Data for this project include quantitative and qualitative data sources.

The qualitative data sources include one-on-one and focus group interviews with coordinators and teachers. Data were also collected via digital recordings of classroom instruction using the Dimensions of Success Protocol. Transcripts from interviews were saved as .doc and .pdf files. Audio and video digital recordings will be saved as .wma or .mp4 file.

We protected subjects' rights to privacy by collecting the minimum information necessary to meet the aims of this project. We only used data for research purposes with participants' consent.

Plans for archiving data and other research products

Data from this project will be archived and retained for 5 years following the formal conclusion of the project. All paper and hard copy records will be kept in a locked file cabinet in the project director's office.

Decisions surrounding what to use for analysis

Our decisions surrounding the data we used not only for analysis, but also in terms of what we collected always stemmed from our research questions. The two research questions that guided *STEM Excellence and Leadership* were:

> Research Question 1. What are the key characteristics of informal STEM learning environments that best support high-potential students' STEM learning outcomes and teacher practice in rural schools?
>
> Research Question 2. How does long-term participation in informal STEM learning environments impact STEM and academic learning outcomes for rural, high-potential students?

Team members were advised before coding to take care to notice whether or not they were seeing events or conversations that seemed to answer these questions. If they saw things that immediately jumped out at them, the team member would note them by writing down the line number on the transcript or by circling the lines in the transcript. They would later revisit these instances as they coded.

Transcripts

The majority of the qualitative data for *STEM Excellence and Leadership* come from audio and video of each school observation. Once the observation ended, a team member (usually the person who conducted the observation) transcribed the audio or video recording. The transcription would begin within a few days after the observation to ensure that important background details such as who is saying what, physical interactions that took place as the words were uttered, and other non-verbal actions were included to provide the clearest and richest picture possible of the session to others were not present.

Recommendation: The details mentioned in the preceding section help to provide a more accurate analysis and they make triangulation easier and more accurate.

Preparation

After collecting the data, the team member did the following:

- Examined the fieldnotes they made before, during, and after the observation.

  Team members found it helpful to write things like, "Teacher 2 @22:00" when multiple people were speaking at once or when things were unclear. As they listened to the recording, they looked at the notes they had written down when they reached that part of the recording. Start and end times for each session were part of the fieldnotes.

- Began their transcript with a description of the room set up (i.e. how many people are present; how many teachers; how many students; number of males; number of females; demographics of group including approximate ages or grade level of students; ways in which people are sitting or standing/ways in which the space is configured- (i.e. tables/individual desks); ways in which the students are grouped together-did they place themselves into groups?; did the teachers put the students into groups?)

- When possible, they included a short description of the lesson the group was working on if they were able to discern in advance and included it in their fieldnotes. It was very helpful to have this information, so efforts were made each time to ask the teacher what they were working on. When possible, team members tried to obtain artifacts such as lesson plans or worksheets from the teacher.

  Once the team member was satisfied that they provided as much background detail and description as possible, they started to transcribe. Transcripts were always written with the goal of providing such clear and detailed description that what took place in the classroom would be readily apparent to anybody reading the transcript.

Transcribing the media (audio and video)

After the background section was completed, the researchers began to transcribe. Most institutional review board regulations require researchers to use pseudonyms for all students and teachers. Many journals require even further confidentiality in naming. This was something the researchers kept in mind, and it guided practice throughout the data collection, analysis, and storage phases of the study. In the case of *Excellence,* the IRB regulations stated that the team must use pseudonyms to protect confidentiality, so the team used labels such as 'Teacher 1' and 'Teacher 2' or 'Female teacher' and 'Male teacher'. Similarly for the students, 'Student 1', 'Student 2', or in some cases 'Girl 1', 'Girl 2' was permissible and in line with IRB requirements.

Recommendation: Follow the guidelines above and below as you note each speaker.

There were times when multiple people spoke at once. In those instances (and there were many times this happened), we noted it as follows:

1. *Teacher 2: What did you find when you tested our hypothesis?*
2. *Student 1: Which time?*
3. *Teacher 2: The first time*
4. *Multiple students speaking at once: (incomprehensible due to numerous voices)*
5. *Teacher 2: One at a time. Hands please.*
6. *Students raise their hands.*
7. *Teacher 2: Yes?*
8. *Student 3: We discovered that the volume changed.*

It was very common for parts of conversations to become inaudible due to the distance from the microphone, speaking styles, background noise, multiple conversations occurring at once, etc. When this happened (and it often did) the transcriber would replay the audio until it became clear. If it remained unclear on the fourth time the transcriber played it, then we noted it like this:

1. Teacher 2: What did you find when you tested our hypothesis?
2. Student 1: Which time?
3. Teacher 2: The (inaudible) time
4. Multiple students speaking at once:(incomprehensible due to numerous voices)
5. Teacher 2: One at a time. Hands (inaudible).

6. Students raise their hands.
7. Teacher 2: Yes?
8. Student 3: We (inaudible) that the (inaudible).

When off-topic conversations happened, the researcher transcribed the audio and video only if had some relevance to the *STEM Excellence* program activities. The exception to this being utterances that indicated relationships between students and teacher, between the students themselves, or when they heard conversations about things that are unique to rural settings. Additionally, conversations regarding issues related to poverty, isolation, bullying, and identity were transcribed when they appeared in the recording.

If there was anything in the transcript that was unclear or did not make sense to any team member who did not prepare the transcript, they were required to contact the transcript preparer immediately for clarification.

We added line numbers to each transcript and then labeled the file as following:

SchoolnameDateObservation (i.e. Schoolname102418Observation)

We then saved the transcripts, audio files, and video files in our secure drive in accordance with IRB and NSF rules.

****Very important****

Do not save transcripts, audio files, and videos anywhere other than the shared drive. Keeping transcripts in any spot other than on the secure server is a direct violation of IRB and NSF rules and regulations.

We were required, at all times, to follow the exact steps we outlined when we applied for the grant that funds this program. (See 'Grant Requirements' section.)

Coding

First level

After transcriptions were completed, the team met to plan how they were going to code.

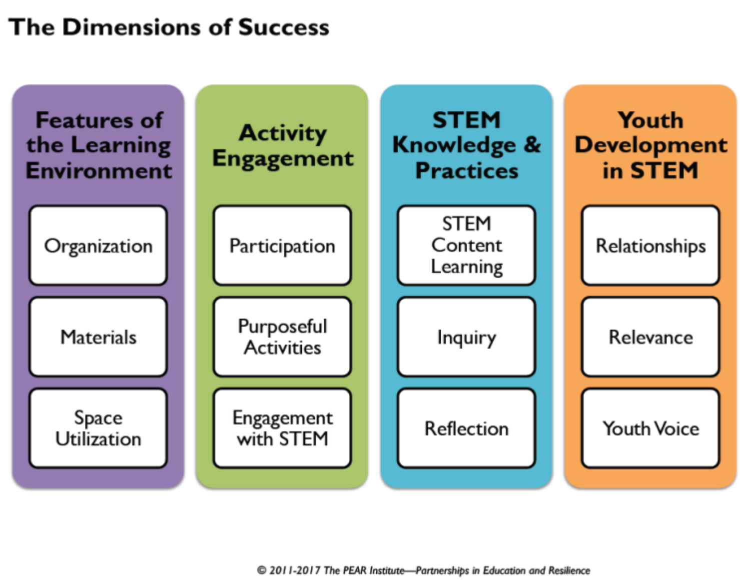
A priori codes

A priori codes are themes that the team decides upon before they begin to code the data. Using a priori coding is helpful in team settings where there are multiple coders as it is a way to ensure intercoder reliability. In our research team meetings, we discussed thematic elements that helped us to answer the research questions we sought to address.

Dimensions of Success

A major example of a priori coding that we frequently employed is the Dimensions of Success protocol. Depending on the focus of the study, this may help to directly inform answers to the research questions; it can be especially helpful if including discussion on the quality of the lesson/activity, and in studies that look at STEM learning and practices. The Dimensions of Success categories are found below.

Additionally, we used a priori codes that were not part of the Dimensions of Success tool. Themes such as motivation, rurality, talent search, and talent development were frequently seen during our observations. Each team member had a list of these codes next to the transcripts as they began to code. The first version of coding that we did was coding for the a priori themes.



Subsequent levels of coding

Inductive codes

Inductive codes are codes that the researcher develops as they are directly examining the data. These are the themes that you see emerging as you read through the transcript. There are many different ways to establish inductive codes. In the planning meetings that took place before each volume of data was analyzed, the research team established the norms for the type of inductive coding they wanted each member to use.

Inductive analysis examines the repeating patterns and themes that have emerged (Percy, et al p.80) and are then synthesized together into a composite synthesis which attempts to interpret the meanings and/or implications regarding the question under investigation.

We used a variety of inductive coding methods on *STEM Excellence and Leadership* including the methods described below.

In-vivo coding

In-vivo coding places particular emphasis on what the participants are saying out loud. In-vivo coding is often used by researchers who want to piece together language and social interactions (Manning & Kunkel, 2014). We used in-vivo coding because we sought to analyze each of the events taking place during *STEM Excellence* sessions. We looked to see what emerged from the interactions that took place as the students and teacher were engaged in enriching STEM curriculum, and the role that the lesson played in helping these students develop the skills and motivation necessary to take the highest-level math and science courses in high school and beyond. Of particular interest were the relationships between the students, students and teacher, and students and materials as they met in their *STEM Excellence* group. In-vivo codes changed each time we conducted a new study depending upon the focus of the research. In-vivo coding was an especially important part of coding when coupled with the orange category listed in the Dimensions of Success tool that is featured above. Something that must be considered in analysis is how the in-vivo codes relate to the a priori codes you selected. We did this throughout our data analyses.

Axial coding

After the team initially coded their data, they examined how the themes they found related to each other. Ideally, the codes should “talk” to each other. Questions that guided this process were: What are your a priori findings? How do your inductive findings support or contradict a priori findings? It often required subsequent rounds of coding to find the answers to these questions, but they were an important part of data analysis since the findings are the story of what took place in the classroom. The team constantly worked to make it clear to anybody using the data set that what they were claiming truly happened during the observation.

Important considerations throughout the coding process

The questions below are the major considerations that guided the team through the coding process

- What are you seeing in the data that answer the question? How does what you are seeing in the data answer the research question?
- What are you not seeing in the data that prevents you from answering the question?
- Do you have findings in the data that contradict other findings within your data?
- Do you have major findings that are completely unrelated to the scope of your study/findings that overshadow themes that answer or refute the research questions?**

**If, after subsequent readings and analysis of the data these themes persist, leave them in your coded document and discuss them with the research team. If they do not persist upon further review as you code, delete them, but note them separately with a page number and line number listed so that other members of the team can see what your thought process was as you read through the data.

The *STEM Excellence and Leadership* team always coded qualitatively without knowing quantitative data. We looked for themes within individual transcripts. Then we grouped transcripts by efficacy levels that we established, such as: least effective; effective; most effective. We then looked for themes within each group. After that, we looked for themes across the three groups. We examined our findings to determine whether or not anything different was happening among groups. It is important to look for the extent that these things happen.

Each team member worked to be certain they were coding for both the team-determined themes, and according to the goals the team had set. Team members were always supported and encouraged to always ask a fellow team member for help when they needed it.

Coding process

When they were ready to code, team members copied and pasted the transcript they were working with into a new word document. It was very important that they did not code directly on the original transcript as it was important to preserve an uncoded version of each transcript from each observation and interview for future coding to be possible.

Each researcher has an organizational and visual process that works best for them. For *STEM Excellence and Leadership* coding, however, we used the method described below for the first through third rounds of coding in order to ensure accuracy and reliability:

Read through the entire transcript at least three times. Get clarification of anything that you don't understand in the transcript. Read it one more time once whatever was previously unclear has been explained to you by the transcript preparer.

- Code line-by-line. Look at each line of the transcript or chunk of dialogue. Colors will be assigned to the themes. When you see that theme emerge, highlight it in the color that corresponds to the theme you're seeing. If you have utterances or events that fit into more than one theme, indicate this by highlighting each bit of it in each theme color.
- After you've done this throughout the transcript, go back again to see what you've missed. If you change your mind about something you thought was there during the first time, note it in the margins. Do another pass of the transcript a third time.
- Keep a master list throughout the coding process of each of your codes. You should be able to clearly communicate each and every single code you used to the rest of the team and to your audience.

Organization suggestion

If it is more helpful to you visually, you can create an additional document where you pull out lines of the transcript and organize it around themes. Keep all versions of your coding and any notes you have compiled during the process and bring them with you to research team meetings.

An example of this is on the following page:

TABLE 17.3 Categorization of Responses to the Open-Ended Question, What are some specific problems needing action in your organization?

Inductive Categories	Participant Responses
Management issues	There are leadership problems. We need a suggestion box. There is a lack of attention to individual needs. There is favoritism and preferential treatment of staff. Decisions are often based on inaccurate information. We need consistent application of policy.
Physical environment	We need a better cleaning service for the office. Our office furniture is dated and needs replacing. We need more computer terminals. There is not enough space for everyone.
Personnel practices	We need more objective recruitment and hiring standards. We need objective performance appraisal and reward systems. Nonproductive staff members should not be retained. There needs to be better assessment of employee ability and performance so that promotions can be more objectively based.
Employee development	More training is needed at all levels. Training is needed for new employees. Many employees are carrying the weight of other untrained employees. We need more opportunities for advancement here.
Intergroup and interpersonal relations	This office is "turf" oriented. There is a lot of "us and them" sentiment here. There is a pecking order at every level and within every level. Communication needs improving. There is too much gossiping and criticizing. Certain departments are put on a pedestal. Each department has stereotypes of the other departments.
Work structure	There are too many review levels for our product. Too many signatures are required. Responsibilities at various levels are unclear The components of our office work against one another rather than as a team. There is a lot of overlap and redundancy. Our product is not consistent because there are too many styles.

(Prochaska, 2013)

Interrater reliability

Dimensions of Success and coding methods

Each member of the *STEM Excellence and Leadership* team was trained in Dimensions of Success. This training helped us to be more reliable in making our claims. At the research team meetings, we collectively decided upon the other types of coding that we would use for each study. Having the same training background helped us to ensure that we have consistency in our methods and that we sought the same answers to the construct under study.

Additionally, the codes we used, and our findings were discussed in depth during research meetings in order to ensure that each team member saw what informed the coding decisions of the other team members.

Example of organization of evidence for codes shared at team meeting for triangulation purposes:

Engagement with STEM	Students are exploring chemistry in a hands-on way, but there is no explicit discussion about how these hands on actvities are helping them to learn specific STEM concepts. They are going through the motions. Facilitator does attempt to tie in discussion of the scientific method, and to get students to define variables but it only happens at one point during the session and only after the students have engaged in a few activities **(lines 661-669)**
STEM content learning	Very limited discussion regarding the specific STEM content they were learning. Facilitator does a good job of helping students to formulate questions and conclusions, but little to no discussion of why they got the results they did **(lines: 811-884)**
Inquiry	Students are engaging in STEM practices themselves due to the hands-on nature of the activities. But the facilitator doesn't explain things like controls for experiments **(line 590)** or prompt for hypotheses **(lines 606-614)**
Reflection	In the first activity there is some facilitator prompting of discussion around what was happening, but it is not in depth **(lines 292-301).** There is some evidence of the students being prompted for reflection in the second activity, but only in the form of superficial questions related to the scientific method and about definitions of general experimental terms **(lines 711-723; 746-749; 818-820)** and not about the actual activities themselves and how they related to STEM content

Credibility measures (validity)

Triangulation (internal validity)

Triangulation occurred by team members discussing the trends and patterns they saw in the data sets. In-depth conversations where each member provided evidence in the transcript for their findings happened for each observation. Triangulation meetings took place weekly, and in some cases, twice per week depending on the study timeline.

Transferability (external validity)

Transferability is achieved by using thick descriptions throughout the study. As we discussed our findings and implications, we used thick, rich description to explain with as much detail as possible what happened, why it happened, and what it meant. We worked to code our data in ways that made this as easy as possible. We also made it a point to include a description of the bigger picture, or in the case of *STEM Excellence* the community at large, as we were examining the effectiveness of an enrichment program in under-resourced schools.

Example of site description for one of the *STEM Excellence* schools

During the observation period, students in School D spent time working on projects that had a very personal significance. Flooding had recently taken place in this district and many students resided in homes that had experienced a great deal of flood damage. Teachers taught several units on weather, climate, and engineering. The students were given the challenge of designing flood-proof structures. Class periods during this unit involved direct teaching, multiple discussions which were very lively during the observation, and informal debates that emerged during the discussions.

Students in this school initiated another very personal project during the observation period. Food insecurity was an issued that impacted many families in the town. A group of students in the seventh grade wanted to help address this issue. They decided to create a hydroponic vegetable garden that could produce enough vegetables to provide regular grocery delivery to struggling families. They used their developing knowledge of biology, their existing knowledge of the norms of their community, and their existing and developing knowledge of agriculture to create their garden. Teachers served as a resource in helping them to procure materials and to offer advice on types of vegetables and crop yields, but the program was entirely student-created and led.