Proposal Submission to the US Department of Education:
Education Innovation and Research (Early-Phase) Grant Program

The STEM Career Prep Model
Program Narrative
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I. ABSOLUTE & COMPETITIVE PRIORITIES

Lumity seeks support to further research, refine, and codify our field-tested strategies into a validated model, The STEM Career Prep Logic Model (The Model), by meeting EIR's priorities in multiple ways: **Absolute Priority 1 (Rationale):** Underpinning The Model is a rationale (or logic model) that combines high quality components—using evidence-based research on STEM professional skills development, computer skills acquisition, social-emotional (SEL) growth, experiential learning, and program implementation—into an innovative approach that prepares high need students for STEM careers. The Model adopts and adapts a number of WWC-validated strategies: connecting school work to college and careers; surrounding students with mentors to foster and support their college aspirations; exposing students to role models in STEM careers; creating classroom environments that spark and continue student interest in STEM through high quality curriculum; and connecting math and science learning to careers in ways that promote diversity. **Absolute Priority 3 (Field-Initiated Innovations):** The Model builds on the above evidenced-based strategies to innovatively prepare high-need students for STEM college and career opportunities in key ways: 1) Lumity builds students tech and coding skills by training our partner schools' teachers in Code.org's coding curriculum and supporting its implementation into STEM courses; 2) Our partner schools integrate Lumity's STEM Career Readiness curriculum into core courses to develop students' SEL and professional competencies; 3) Lumity's Real World Projects and One-Day Challenges then require students to apply STEM skills and career and SEL competencies by designing STEM-based solutions to community, city, and business problems supported by business mentors; 4) Lumity provides 4 weeks of summer STEM enrichment following grades 9 and 10; and 5) Lumity guides students in determining and transitioning to a STEM college/career path, including facilitating career-site experiences with corporate partners. **Competitive Priority 1:** Lumity's model expands access to and participation in rigorous computer science coursework for traditionally underrepresented students (African American (31%), Latinx (45%), females (50%), disadvantaged socioeconomic backgrounds (83%)) by training and supporting teachers at partner Chicago Public Schools in learning and implementing Code.org's curriculum in required computer science courses.

II. PROJECT NARRATIVE

A. Significance

A1. Potential Contribution. Lumity, in partnership with the Chicago Public Schools (CPS) and more than 25 large, diverse companies, such as Accenture and Google, is engaging high-need teens with transformational experiences to prepare them for STEM careers. We seek support to further research, refine, and codify our field-tested strategies into a validated model, The STEM Career Prep Logic Model (The Model). We begin with three partner high schools, starting with 325 students in cohort A beginning in 2019-20 school year and 325 students in cohort B beginning in 2020-21 (650 total) in The Model study, with 650 students in the control group. Our evaluator, Outlier Research & Evaluation/UChicago STEM Education at the University of Chicago (Outlier), will conduct a mixed method randomized controlled trial design to understand 1) The Models' **impact** on students' academic, social-emotional, and identity/attitude outcomes on STEM and STEM careers—isolating the components that seem to be the most important; 2) the **implementation** variances and the effects of staff abilities and perceptions on student outcomes; 3) the impact of **external factors** on both implementation and outcomes. As findings emerge over the course of the grant, Lumity and partners will revise and continue to implement our strategies with the incoming student groups at these schools impacting over 1,000 students.

Lumity's Model furthers the understanding of key educational problems and tests promising solutions. Using market research, we've identified **the skills STEM careers require**—back mapping from these The Model's experiences that teach students the skills necessary to access career opportunities**.** Then, we've identified **the gaps between student achievement and economic opportunity** by analyzing the learning needs of students traditionally underserved by the education system. Finally, Lumity has identified and targeted the **opportunity for educational change:** Our model fills the current gap in STEM learning for these students by creating a new type of STEM experience that is engaging, builds their marketable skills, and allows them to "see themselves" in a STEM career. In further detail:

1) The skills STEM careers require. The Model will prepare high-need students for STEM careers—the fastest growing fields that drive innovation across sectors and offer high wage opportunities for those with relevant skills and experience. Analyzing data from its 500 million members, LinkedIn recently identified the top 25 hard skills currently in demand by employers: 19 are STEM related (e.g., cloud computing, UX design, video

production, game development) and the remaining, including sales leadership and customer service systems, are valuable to all STEM companies (Petrone, 2019). This demand is expected to continue based on the U.S. Bureau of Labor Statistics' employment projections, which suggest that the STEM fields will have significant job growth (more than 15%) and high median wages through 2026, particularly in software development (systems and applications), computer and information systems, information security, medical management, and operations management (2016, revised 2018). Illinois and Chicago mirror the national trend in the demand for high wage STEM occupations, making our area a prime environment for improving, testing, and codifying new approaches to STEM-related education for high need youth (IL Department of Employment Security, 2019).

According to the World Economic Forum, young people with strong STEM skills will be well positioned for the rise of automation and computing applications expected over the next 10 years (2016). The World Economic Forum also notes that these shifts will demand that young adults have a strong set of social-emotional skills (SEL)—complex problem-solving skills, critical thinking, creativity—to be successful (2016). There is emerging evidence that employers value SEL skills, or "soft skills," as much as STEM skills (Deming, 2017), with LinkedIn research finding that 57% of senior leaders saying "soft skills are more important than hard skills" (Petrone, 2019; LinkedIn, 2018). Google, for one, found that the characteristics that defined the most successful employee teams were social-emotional skills, such as shared conversation, social sensitivity, and time management (Duhigg, 2016). As Harvard professor David Deming asserts, "Social interaction is perhaps the most necessary workplace task for which there is currently no good machine substitute" (2017). Based on our research of marketplace demands, Lumity's Model builds student experiences so that they are learning and applying both computer science and professional "soft" skills in ways that are real and relevant to current and future careers.

2) The gap between student achievement and economic opportunity. While careers in STEM continue to grow, too many students, particularly low-income students and/or minority students are not prepared to access these opportunities. For students in our partner schools, like many high need urban schools nationally, the pathway to STEM careers is daunting. While the promising news in Chicago is that high school graduation rates (75% in 2017), 4-year college entrance rates (47% in 2016), and 4-year college completion rates (49% in 2015) have all increased significantly over the past 10 years, the raw numbers are still sobering: Of the 30,000 freshmen who enter CPS each year, approximately 5,200 (17%) graduate from college (Nagaoka & Seeskin, 2019).

Moreover, for those who drop out or don't pursue post-secondary education, their career options are limited. For Chicago youth ages 20-24, only 32% of those without a high school diploma are employed (Sum & Khatiwada, 2012, p. 7)—slightly higher than the 30% national unemployment rate for high school dropouts (Bureau of Labor Statistics, 2015). A 2017 study by the Great Cities Institute/U.Illinois found that Chicago's "youth joblessness continues to be disproportionately felt by young people of color, especially black males; that it is *chronic and concentrated*; that the recession made conditions worse and that for some, recovery is either slow or nonexistent; that it is tied to long term trends in the overall loss of manufacturing jobs; most notably, that joblessness among young people is tied to the emptying out of jobs from neighborhoods…"(Cordova & Wilson p.iii **).** In Chicago, and across the nation, too many students are not prepared for the current and future economy.

3) The opportunity for educational change. While this data is specific to Chicago, it is not unique for large and mid-sized cities in our nation. Data on our partner high schools mirror high-need, large and medium-sized urban districts across the nation, making findings from The Model significant to solving this common challenge at scale. These young adults, like many others, traditionally do not have access to the types of learning experiences that engage them in STEM, develop their STEM skills with SEL competencies, and connect them to post-secondary STEM opportunities. Policy brief *STEM 2026* sums up the opportunity for change in STEM preparation: "strong STEM pedagogy and resources are typically lacking in schools serving disadvantaged students, and many of the programs that are available aim to address a perceived deficit with the student, rather than a focus on changing the system and delivery of STEM instruction to more effectively support and draw on students' strengths" (Tanenbaum, 2016, p.3). Moreover, students don't have the opportunities to connect STEM learning "to everyday bodies of knowledge, experiences, practices, and community" (aw. Lopez, ja. Mejia, im Hasbun, & gc. Kasun, 2016)—to "see themselves" in a STEM career. Many students are not taught what it takes—academically and social-emotionally—to make it in STEM and do not have the necessary guidance to turn "funds of knowledge, defined as the knowledge, skills, and practices developed through historical and cultural interactions" (Moll et al. 1992; Upadhyay, 2006) into a pursuit of STEM-related careers (Wai-Ling Packard, 2016; Funk & Parker, 2018). While these challenges seem significant, Lumity and our partners are using them as catalysts to take a fundamentally different approach to engaging underserved youth in STEM.

A2. Promising Strategies. Background: Lumity's emerging strategies. The Model builds on, tests, refines,

and codifies our emerging STEM learning strategies that are beginning to show impact with our pilot schools: a) Teaching students career skills and SEL competencies **through in-class, interactive lessons; b)** Engaging students in developing and applying STEM, career, and SEL skills **in Real World Projects and One-Day Challenges with STEM corporate volunteers to design solutions to real world problems; c)** Connecting students with area business leaders through STEM Talks **so students hear and see how people from similar backgrounds are successful in STEM; d)** Exposing students to STEM careers **via Corporate Site Visits; and e)** Reinforcing STEM career readiness by providing **4-week summer enrichment courses** following grades 9 & 10**.** Our pilot high schools are culturally, ethnically and economically diverse. School and student performance vary and, while graduation rates are strong, most students are required to take remediation courses in college.

Each school is unique, but all are dedicated to improving STEM pathways. Table 2 shows the co-development of Lumity strategies based upon each school's needs and priorities over the last few years.

Lumity is analyzing our impact to date, and, if funded by the EIR grant, Outlier will lead a rigorous third-party quasi-experimental study on the effects of a full-scale model. Currently, student reports suggest that after just one

[1] **RWP-** Real World Project **ODC-** 1-Day Challenge **CSV-** Career Site Visit **SCR-** STEM Career Readiness Module

semester with Lumity experiences, they are better able to work with others, manage their time, and persist through challenges. A deep-dive on [redacted] data shows the contribution of the Lumity strategies to the school's overall improvement efforts. From 2014 to 2018 the school rose from being in "intensive support" to "good standing plus," (CPS, 2018), and the school improved on multiple measures (IL School Report Card, 2018)[2].

Moreover, feedback from our partner schools highlights the importance of Lumity's strategies in creating robust experiential learning for students.

[redacted]

Next Steps: The Model's promising approach to STEM Career Readiness. The Model is promising in that it brings together our emerging strategies—along with computer sciences courses using Code.org's curriculum—to further implement, test, and refine into a promising new STEM Model that: 1) builds students' computer science skills; 2) aligns in-school learning and authentic STEM career experiences; 3) scaffolds and connects students' STEM, career, and SEL skill-development grades 9 through post-secondary**;** 4) improves student access to STEM careers; and 5) takes corporate/school partnerships to the next level, creating STEM career networks for students. Through our strong relationships and our evaluator, Lumity is well positioned to implement and test this new model to evaluate its impact on students. The varying school sizes, approaches, and cultures will shed light on model implementation and impact in different contexts. The Model is designed on the following research-base:

- **Building students computer skills, particularly coding competencies:** Lumity leads the training of teachers in implementing Code.org's research-based curriculum and professional development. Both the training components and curriculum are endorsed by the College Board as aligned to its research-based AP curriculum framework standards, assessment and framework for professional development.

- **Focusing on specific SEL content that connects to STEM career readiness**. The Model's SEL content includes: Developing a growth mindset (Dwek, 2006 & 2012); Developing meta-cognitive skills (Steinberg, 2011;

[2] Refers to CPS' quality scale: 1+ (good standing)-3(intensive intervention) using multiple metrics (attendance, graduation)

2012 & 2013; Siegel 2007, 2011; and Davidson, 2012); and identifying and understanding emotions and stress (McGonigal, 2016; Robert Levenson, 2013; & Stephane Cote, 2010 & 2013).

- **Implementing experiential learning strategies.** Learning experiences are anchored in experiential learning research—Dewey, Lewin, and Kolb— so that they are interactive, pro-active and self-driven (Dewey, 1897) and students "learn to learn" through observing, reflecting, and forming and testing concepts (Kolb 1984). Within each strategy, students develop skills through collaboration, task interdependence, and group dynamics, learning to be successful as a group leader and team member (Lewin, 1948).

- **Integrating isolated, but promising, SEL approaches into a comprehensive student experience for career readiness.** Lumity connects disparate SEL approaches, identified by Harvard Prof. Stephanie Jones and researcher Suzanne Bouffards (2012), into a comprehensive model with real world applications that includes: consistent SEL development; connecting SEL and academic development by integrating career skills with rigorous STEM content and instruction; and recognizing that SEL skills develop in a social context by maximizing interactions between students, students and corporate volunteers, and students and teachers. Lumity's career skills lessons are sequenced based on research by Marvin Berkowitz (2005).

- **Developing working relationships with STEM professionals so students can "see themselves" in STEM careers.** By pairing STEM professionals with students to solve real challenges, Lumity creates authentic work connections and experiences. While more research is needed on the impact of mentoring on students, there are studies that show a correlation between career-embedded mentoring and student interest and commitment to STEM studies and careers (Patel et al, 2015; Pentyala, Dilger, & Rebecchi, May 2016).

- **Supporting implementation through professional development.** Lumity leads The Model's implementation by facilitating professional development (PD)—teacher orientation and workshops, co-planning, and co-teaching—designed from research including the College Board's professional development framework, Jones' and Berkowtiz's research on integrating SEL instruction, and Darling-Hammond and team's findings outlined in *Effective Professional Development* (2017). The training focuses on developing teacher expertise in implementing The Model's components through interactive teaching strategies with students (e.g., peer discussions, role playing, and cooperative learning; explicit instructional strategies of career and SEL skills; and

modeling and mentoring). A key focus of Lumity's PD is integrating continuous improvement (see below) so that teachers "have opportunities to think about, receive input on, and make changes to their practice by facilitating reflection and soliciting feedback" (Darling-Hammond et.al, 2017). (See *Appendix* for PD conceptual framework).

The above research is embedded throughout The Models' components. As described in *Program Design*, the components are scaffolded 9th-12th so that students build skills over time and experiences intensify as students prepare and transition to post-secondary. Based on our emerging strategies, The Model's components will include:

- **Computer science skill development in the pilot school's computer science courses.** All students participating in The Model will complete Code.org's CS Principles curriculum at their schools (typically in 10th or 11th computer science courses) that will build the skills necessary for STEM post-secondary opportunities/careers. In year 1, Lumity will train 3-6 teachers across pilot schools in learning and implementing CS Principles through a summer week-long training session with the equivalent of 24-hours of follow-up coaching to support their implementation throughout the academic year. CS Principles includes 5 course units (Structure, Design & Challenges of the Internet; Encoding, Representing & Manipulating Digital Information; Intro to Programming; Big Data & Privacy; and Building Apps); 2 Performance Tasks for AP Computer Science; and an Ongoing Data Tool development project. (See appendix for additional curriculum information and examples).

self-management); 3) Practice and apply STEM and SEL skills through STEM challenges using inquiry-based instruction; and 4) Build their personal brand through goal setting and college/career planning; resume, LinkedIn and other online profile development; interview practice, etc. Together, these experiences will point students toward STEM careers that interest them and begin to build the skills those careers demand—skills not taught in subject area courses in most high schools.

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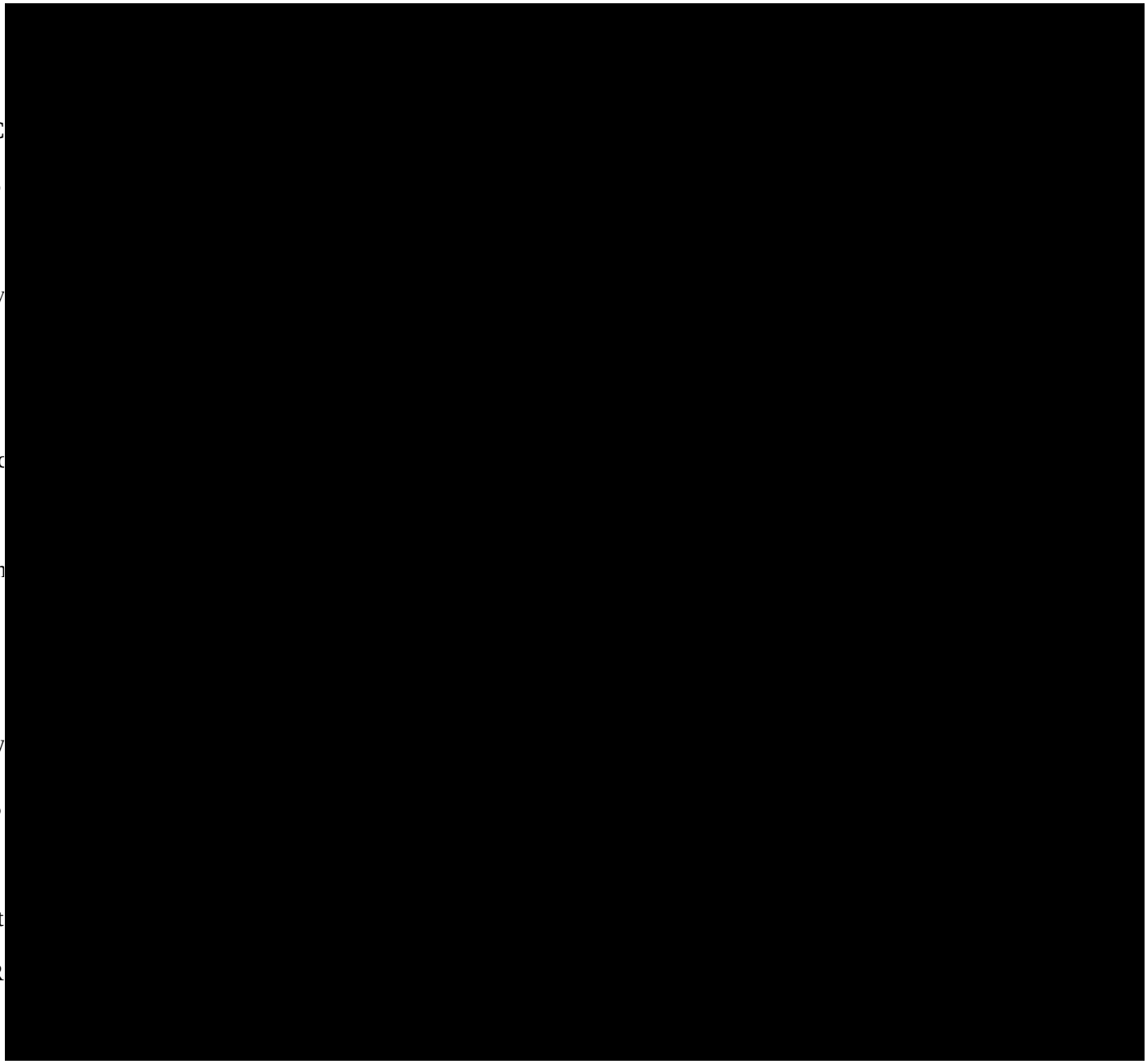

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- **STEM Talks** will connect students with STEM leaders and engage them in career networking. Like the other components, the STEM Talk experiences will be scaffolded over time to meet the different developmental needs

of students at each grade level. In 9th and 10th grades, students will engage in small group conversations with STEM leaders who will share past challenges and choices and bring to life what students are learning through examples of their own personal and career journeys. Students learn how STEM leaders leveraged mistakes into achievements, set goals, and navigated high school, post-secondary, job interviews, and daily STEM work life. Prior students report that the STEM Talks helped them imagine future possibilities and connect those possibilities to actions they can take. In 11th and 12th, students will practice active networking with STEM leaders to learn to navigate the transition to college and careers and form their own professional networks with STEM leaders.

- **Career Site Visits (CSV),** hosted by our corporate partners, provide students with interactive experiences about industries, workplaces, and job opportunities and responsibilities. The CSV allow students to continue deeper conversations about STEM career readiness with STEM leaders and helps them visualize themselves in similar STEM-related careers and work places. Structured by the host company, the visits for 9th and 10th graders include a corporate tour, meeting STEM leaders to learn about their career paths, and completing a job-related interactive project. For 11th and 12th grades, students will participate in job shadowing opportunities with potential opportunities for summer internships.

B. Quality of Project Design

B1. PROJECT DESIGN: Goals, objectives and outcomes. The Model seeks to impact participating students in three key areas: student academic success, student development of emotional and social skills, and student access to STEM careers. **Overarching Goal:** In the long-term—at the end of the grant and beyond—Lumity's goal is to have a sustainable model that increases the number of African American, Latinx and female students and/or students from disadvantaged socio-economic backgrounds who pursue STEM careers and become STEM leaders. **Long-term Outcome:** The Model will ultimately result in at least 25% of participating students holding a position in a STEM career. Measured by: Lumity will collect data via surveys of alumni about their employment status, job title, industry, and wages. An initial survey (via LinkedIn and social media) will engage 2011-2015 graduates who never participated in any Lumity programs and 2016-2019 graduates who participated in our first phase of strategies. Then, we will conduct follow-up surveys with alumni who participate in The Model for 2-5 years post-program via LinkedIn accounts they establish in 12th grade. **Long-term Targets**: Our targets that will lead to the

overall result of 25% of students in STEM careers: 1) **90% of participating students graduate high school within 4 years.** Measured by: Annual data collected by Outlier for Cohorts A and then Lumity; 2) **70% pursue 4-year post-secondary education and/or specialized training**. Measured by: Post-secondary enrollment data and/or surveys of graduates collected by Outlier for Cohort A and then Lumity; 3) 7**5% persist to achieve a B.A./B.S.** Degree. Measured by: Surveys of alumni on college completion collected by Lumity through LinkedIn accounts they will establish in 12th grade.

To track progress toward the above outcomes—and provide insight into the immediate outcomes for students participating in The Model—Lumity will work with Outlier to create benchmarks and set interim targets against which they will collect, synthesize and analyze student data on students' academic achievement, SEL competencies, and career awareness.

Short-Term Outcome 1 - Student Academic Success. Outlier will track and analyze two measures for participating students by school: On-track toward Graduation (course credits and grades) and On-track to College Readiness (SAT assessments). Targets: Outlier will use historical district- and school-level averages for 4 years prior to Lumity as a baseline and to create targets.

Short-Term Outcome 2 – Student Social and Emotional Development. Outlier will look at two outcomes: 1) Truancy rates and 2) Discipline referrals. Targets: Pre-measurements will use historical district- and school-level averages for the 4 years prior to The Model to set baseline and targets.

Short-Term Outcome 3 – Career Awareness. Outlier will conduct annual pre/post student surveys on relationship with professional mentors, perceptions of STEM & perception of and plan for STEM careers.

Implementation Objective 1. Outlier will measure the impact of Lumity's work with teachers by measuring teacher understanding of The Model and its implementation; perception of their participation; and perception of impact on student outcomes. Measured by: Teacher completed questionnaires and interviews.

Implementation Objective 2: Outlier will measure the impact of Lumity's work by measuring school leaders' understanding of The Model's implementation and perception of impact on teacher practice & student outcomes. Measured by: Questionnaires and interviews.

[redacted]

B3. <u>Program Design:</u> <u>Feedback and Continuous Improvement</u>. Lumity, our corporate and school partners, and Outlier are committed to continually collecting, analyzing, and using feedback data on inputs, outputs and outcome targets in a continuous improvement cycle so that The Model becomes more effective for students and teachers and the partners become more efficient in the way we work together. We expect that to implement The TQM Model that we use with students for our own work, adjusting the steps as necessary (see *Promising Strategies* for details). We will coordinate improvement on two levels:

1. **Overarching Model Improvement:** Lumity will facilitate TQM Continuous Improvement process with leadership from our key corporate partners and schools to drive overarching programmatic improvements. Outlier will serve as a "critical friend" by synthesizing data, providing analysis and insights, and contributing solutions to test. To facilitate continuous improvement process, we will leverage our current meeting structures (described in *Program Management)*:

- <u>Advisory Committee</u> - leaders from Lumity, key corporate partners, schools and Outlier will meet quarterly using TQM to look at program-wide data, make strategic decisions and formulate next steps, including refinements to the overall Model and its implementation.
- <u>School Working Groups</u> - Lumity and school leaders (administrators and teacher leads) meet at least three times annually to use school-specific data to make school-based refinements. To facilitate

continuous improvement with these structures, Lumity and Outlier hold annual planning meetings, bi-monthly continuous improvement meetings, and ongoing informal touch points as needed to support data collection, analyze Outlier's synthesized data and frame and plan for the Advisory Committees and Working Groups agendas.

2. **Day-to-Day Improvements**: Lumity will also use the TQM continuous improvement process to respond to and improve our day-to-day work between the larger team meetings, adjusted as needed, in three ways: 1) Internally with Lumity program staff in leadership/program weekly meetings and on-going PD; 2) Through PD with pilot classroom teachers in biweekly professional learning communities (PLC) with Lumity program staff supporting the implementation of inquiry-based instruction; and 3) With corporate volunteers to debrief within a week following an event to adjust students' career experiences. We will use the data collected by Outlier, as well as ongoing student artifacts and data from our curriculum lessons and Model experiences collected by Lumity staff.

As outlined in The Model, we will analyze input, output, and outcome data as part of our continuous improvement process to drive planning (See *Rationale* and *Evaluation* for more information):

Inputs – A combination of quantitative and qualitative data collection on the following:

- **Staff performance and effectiveness:** Annual student and teacher surveys and interviews by Outlier will include feedback on Lumity staff effectiveness used for performance reviews.
- **Curriculum effectiveness:** *Ongoing:* Lesson plans and the resulting student work artifacts (e.g., written work, observations of presentations, observations of student performance in design work, student assessments) will be collected and analyzed in weekly PLC meetings conducted by Lumity leadership with program staff, as well as in periodic meetings with school staff and volunteers, to identify potential fidelity or curriculum problems for course corrections and planning (and to celebrate successes!). *Annual:* Outlier-led teacher surveys and annual interviews with school staff and Lumity staff include quantitative and qualitative feedback on curriculum appropriateness and effectiveness.
- **Program design quality:** *Ongoing*: Lesson plans and student artifacts (e.g., written work,

observations of presentations and team design work, & assessments) will be collected and analyzed in weekly PLC meetings conducted by Lumity leadership with program staff, as well as periodic meetings with school staff and volunteers, to identify potential fidelity or curriculum problems for course corrections and planning (and to celebrate successes!). *Annual:* Outlier-led surveys and interviews conducted with Lumity staff, school staff and corporate partners.

Additionally, Outlier will also conduct observations in classrooms and Lumity events to measure implementation and the overall effectiveness of the above inputs and isolate the program components (SCR curriculum, Real World projects, One-Day Challenges, STEM Talks and Career Site Visits) that seem to be having the biggest impact on student outcomes. Outlier will conduct up to 24 observations (8 per school) across grades using observation protocols.

Outputs: Annual pre/post student surveys and interviews on their perception of their career readiness growth—attitudes toward STEM and STEM careers, perception of SEL growth—outlined in the rubric; In-depth interview of a group of selected students each year to understand their growth overtime while participating in The Model; and Teacher and leader surveys and interviews based on data, observations, and student work related to student outcomes.

Outcomes: Data collected and analyzed annually on: **Academic***:* Student progress toward graduation (*accumulation of credits and grades)* and On track to college readiness (*SAT scores);* **SEL growth***:* Truancy rates and discipline referrals; and **STEM career evidence***:* Evidence of career pathways plan and qualitative survey data from students, teachers, and corporate volunteers about student connections with STEM professionals.

C. Adequacy of Resources & Quality of Management Plan

C1. Adequacy of Resources & Quality of Management Plan: Management Plan.

Model Roll Out. Lumity and our partners will roll out The Model grades 9-12 at each school (See *Appendix*: 5-year plan), while codifying our approach to reach and impact additional schools beyond the grant.

Table 4: Model Roll Out

Cohort=325 students across schools	2019-20	2020-21	2021-22	2022-23	2023-2024
Cohort A (CA)	9th	10th	11th	12th	Post-Sec
Cohort B (CB)	N/A	9th	10th	11th	12th
Summer STEM Enrichment	CA-4 Wks	CA & B-8 Wks	CB-4 Weeks	NA	NA
650 Students Total in The Model[3]	6-9 Teachers Total	12-18 Teachers Total	18-27 Teachers Total	24-36 Teachers Total plus 3-6 teachers in Code.org	
Phase-In of Course Content Areas for Implementation	ELA	History or Politics	Civics or Science	School-Required Capstone	

[redacted]

As mentioned, additional students will engage in Lumity's model during the grant as new classes enroll in each pilot school subsequent years of the grant (2021-22, 2022-23, 2023-24– and will be impacted by emerging findings regarding The Model components as we improve from this study.)

Teacher Experience and Lumity Supports. We will continue to work closely with school administrators to identify and engage participating teachers, phasing in their participation as the cohorts move to the next grade level: ELA teachers for 9th graders, History teachers for 10th graders, Civics or Physics for 11th and Capstone for 12th. Lumity recognizes that too often teachers see programs come and go. To counteract potential skepticism and positively engage teachers, Lumity staff will work with administrators and teachers in PLC's to co-plan, modeling strategies, co-teaching, and iterating to build trust and relationships (TQM continuous improvement). This PLC approach will help ensure The Model is institutionalized and sustained through teacher practice and will allow for "gradual release" with intensive supports in the beginning that are customized as teachers gain experience. (See *Appendix* for PD strategies). Finally, we will ensure sustainability—and begin to create a way to engage more schools—by developing teacher resources that can be used virtually for development and implementation (e.g., lesson plans, accompanying background research, videos of lessons in action, etc.)

STEM Volunteer Experience and Lumity Supports. Lumity provides guidance in-person and virtually to corporate volunteers to plan for each career site visit and STEM Talk—including a debrief within one week of the event. Lumity will also enhance our current volunteer toolkit (example modules: obtaining background checks, tips on working with youth, program protocols, etc.) to include videos that volunteers can watch when convenient and as needed on a variety of pertinent topics, such as role modeling and how to engage with teenagers but not overstep boundaries.

Roles, Responsibilities, and Partner Coordination. Lumity and our school and corporate partners have well-developed relationships and a collective commitment to students. Lumity Executive Director Kara Kennedy leads cross-org collaboration focused on continuous improvement through three structures:

- **Advisory Committee.** Lumity's Advisory Committee (key corporate partners and reps from each school) meets quarterly to provide overall strategy and use TQM to look at data from the evaluation and make refinements to The Model and implementation.
- **School Working Groups.** Lumity program staff meet at least 3x during each school year with administrators and teacher leads to coordinate implementation, as well as with teachers bi-weekly.

- **Lumity/Outlier Partnership.** Holds annual planning meeting, bi-weekly meetings and informal touchpoints to facilitate data collection and use synthesis to inform continuous improvement efforts.

Work Plan. Table 7 outlines the activities, milestone, group/person responsible, and timeline.

Table 7: The Model Project Work Plan

PLANNING PHASE: (Present -Dec 2019)			
Work Areas	Activities	Due	Responsible
Management	Weekly program team meetings & school working groups (PLC)	Ongoing	Lumity with partners
	Finalize management plan, including hiring and advisory committee	10/19	
Program	Finalize partnerships and components for phase 1, including schedules	9/19	
Evaluation	Finalize evaluation, data collection system and TQM process.	10/19	Outlier
Program	Orientation for teachers and volunteers; Training in Code.org; Tweak SCR curriculum for grades 9 &10 and develop content for grade 11.	7/19	Lumity
Milestones	Planning specifics finalized for phase in for all areas.		
IMPLEMENTATION PHASE 1(SY 2019-2020)			
Work Area	**Activities**	**Due**	**Responsible**

Management	Weekly PLC meetings; coordination of partners; school working groups all focused on TQM problem solving/continuous improvement.	Ongoing & quarterly	Lumity &Partnrs
Program	Biweekly planning (continuous improvement) & co-teaching with teachers.	Biweekly	Lumity w/schools
	SCR curriculum, Site Visits, STEM Talks, & Summer STEM enrichment	10/19	
	Real World Projects	12/19	
	One-Day Challenges	1/20	
Evaluation	Provide data synthesis, critical friend feedback and planning	Bimonthly	Outlier
Program	STEM Fair Competition at Lumity Annual Dinner	3/20	Lumity
	Revise based on evaluation and feedback	Summer 2020	Lumity
	Continued design of curriculum.	Ongoing	
	PD for school staff, corporate volunteers & Lumity staff	July-ongoing	Lumity & partners
Management	Advisory Committee meeting (model refinements, course corrections)	Quarterly	Lumity & partners
	Annual debriefs with Evaluator	Annual	Lumity & Outlier
	Planning for phases 2-4 across orgs and meeting structures	Varies	Lumity
Milestones	Students experience The Model as described in chart above. Model refined based on feedback/data.		

IMPLEMENTATION PHASES 2-4 (SYs 2020-2024)			
Work Area	**Activities**	**Due**	**Responsible**
Management	Weekly PLC meetings; coordination of partners; school working groups all focused on TQM problem solving/continuous improvement.	Ongoing& quarterly	Lumity&Partners
Program	Biweekly co-planning and co-teaching with gradual release	Biweekly	
	SCR curriculum, Site Visits, STEM Talks, & Summer STEM enrichment	10/20	Lumity
	CS Principles in grades 10 or 11 computer science courses	8/20	
	Real World Projects & One-Day Challenges	1/21	Lumity
	Development of job shadowing experiences	By 8/21	Lumity
	PD for school staff, corporate volunteers & Lumity staff	ongoing	Lumity
Evaluation	Provide data synthesis, critical friend feedback and support for planning	Bimonthly	Outlier
Program	STEM Fair with Real World Problem/Project Competition	Annual-March	Lumity
Management	Advisory Committee meeting	Quarterly/year	Lumity
	Annual debriefs with Evaluator	Annual	Lumity
	Planning for financial sustainability and dissemination	Ongoing	Lumity
Milestones	Students experience The Model as described in chart above. Model refined based on feedback/data. Sustainability and dissemination finalized.	Annual	

SUSTAINABILITY AND DISSEMINATION PHASE 5 (SY 2023-2024)			
Work Areas	**Activities**	**Due**	**Responsible**
Management	Partner coordination; Sustainability planning & implementation.	Ongoing	Lumity&Advisory
Programs	Continued model implementation as refined. Dissemination.	10/23	Lumity
Evaluation	Final evaluation report released with impact data	11/24	Outlier
Milestones	Impact on student academic, SEL, and career skills attainment.	1/24	Lumity

C2. Adequacy of Resources & Quality of Management Plan: Key Personnel Qualifications

Lumity, the corporate partners, and Outlier team bring extensive experience and expertise to the project.

[redacted]

[redacted]

C3. <u>Adequacy of Resources & Quality of Management Plan: Continued Support.</u> Currently, Lumity's efforts are mostly supported through a revenue-generating non-profit job board, in-kind contributions from volunteers and corporate giving for direct services to students. The EIR grant is a critical next step, because it provides support for codifying our strategies into a promising Model that is rigorously evaluated by a third-party evaluation – support that can be difficult to obtain from individual and corporate donors who tend to preference programs, not research. During the five years of the grant (if awarded), Lumity will take critical steps to ensure sustainability and continued support. First, we will continue to build out self-sustaining revenue streams. Our corporate volunteers are providing in-kind business development services to increase earned revenue from our online non-profit job board by expanding the service into additional markets beyond Chicago. Additionally, we are piloting new revenue streams, such as a fee-for-service structure for training in Code.org curriculum for Illinois teachers and designing after-school/summer STEM experiences with a fee-for-service structure with After School Matters, CPS and Chicago CRED. Together, this work will help to ensure that our mission to provide transformational STEM experiences for Chicago teens, particularly sustaining The Model in current pilot schools and adding additional schools, will be self-sustaining. Finally, Outlier's evaluation of The Model will provide much needed information about the efficiency and effectiveness of its components and inform revisions to ensure it has an impact on student outcomes. Insights from the evaluation will guide Lumity and the Advisory Committee in planning for scale so that we can efficiently and effectively engage a significant number of schools in The Model, decreasing the cost for participation. This includes using the work and lessons

during the grant period to develop resources that support and sustain teacher implementation at a larger scale, including virtual teacher professional learning experience with curriculum framework, lesson plans, examples of videos of each lesson in action and more. Finally, the evaluation will also serve as a proof point for other partners that The Model has a strong return on investment and is sustainable for all involved.

D. Evaluation

Outlier's research plan uses well-designed research questions, robust data collection, and rigorous analysis strategies to meet The Model's goals. The research plan will generate key findings about the implementation of the Lumity model and its effect on student outcomes, informing local and national STEM education practitioners and policy-makers about transformational experiences that engage high-need teens, prepare teens for STEM careers and contribute to a healthy and diverse pipeline for the STEM workforce. **Research Questions:**

RQ 1: What is the status of Lumity implementation across 4 Chicago-area high schools? A. How does implementation vary within and between schools? B. What are the effects of Lumity on teacher and school staff abilities and perceptions?

RQ 2: What external factors (e.g. other school initiatives, student individual differences) affect implementation and student outcomes?

RQ 3: What are the effects of Lumity on the students' academic, social-emotional, and identity/attitude outcomes? A. Which components of Lumity appear to be have the most importance in student outcomes?

Research Design and Sampling

Outlier and Lumity propose a mixed-method randomized controlled trial design (treatment and untreated control group design with pretest-posttest (Cook & Campbell, 1979)). Outlier collaborated closely with Lumity to design the study and recruit Lumity's high schools to participate. A cluster-level random assignment procedure will be used to randomly assign teachers within each school to either to treatment or untreated control group. **This approach meets What Works Clearinghouse standards without reservations.** Outlier will implement a cohort-sequential, longitudinal research approach over five years (2019-2024). The first cohort (cohort A) will include 9th grade students in the academic year of 2019-2020 (Year 1), while the second cohort (cohort B) will consist of 9th grade students in 2020-2021 (Year 2). Within each cohort, the students are nested within teachers who in turn are nested within each of

the three schools. They will be randomly assigned either to a treatment or control group through cluster-level random assignment procedures (students nested within teacher as a cluster). Specifically, Year 1: 650 students within 12-18 teachers (4-6 teachers per school) Thus, treatment and untreated control group in cohort A (Year 1) will each consist of 325 students (2-3 teachers per school). In Year 2, the same size and assignment procedures will be used for Cohort B. Therefore, starting from Year 2, 1,350 students nested within 24-36 teachers will be equally divided into either treatment (650 students nested with 12-18 teachers) or untreated control group (650 students nested with 12-18 teachers). Having two cohorts will enable us to track a larger sample and to examine any cohort differences as Lumity strengthens its programming from Year 1 to Year 2. This study will examine student outcomes while controlling for teacher-level variables through two-level HLM (Hierarchical Linear Modeling) analyses. Please see Appendix A for a detailed description of power analysis, as well as approaches to manage attrition and contamination.

Data Sources and Measures. Data for the proposed study will come from following sources: 1) student questionnaires and interviews; 2) teacher questionnaires and interviews; 3) school leader interviews; 4) Lumity staff interviews; and 5) extant CPS administrative student outcome data.

Student Questionnaire. Students' attitudes towards STEM subjects and their interest in future STEM careers will be measured through student questionnaires. During a previously funded NSF Study (STEM School Study #1238552), the questionnaire measures underwent several iterations of administration and revision to achieve peak reliability and validity. Lumity has previously used student questionnaires for assessing students' SEL skills and experiences (i.e. self-reports of collaboration, communication, intellectual openness, leadership, and conscientiousness). Outlier will examine and improve on these measures using existing, validated measures such as CORE's Student Social and Emotional Learning Index (Gelbach & Howe, 2018). In addition to addressing student outcomes (RQ 3), these surveys will also be a valuable source of implementation data (RQ 1 & 2). Outlier has over a decade of experience studying the implementation of education interventions (Century & Cassata, 2016) and has developed and validated a number of implementation measures for students and teachers. We will start with these measures and adapt for The Model. We will administer pre-(Sept) and post- (May) student questionnaires

each study year to assess attitudes and SEL. Cohort A will complete questionnaires annually Years 1 to 4, and Cohort B will complete questionnaires annually Years 2 to 5.

Post-Graduation Student Questionnaire. At the end of Year 4, Outlier will administer a post-graduation questionnaire to Cohort A students who have provided contact information for Year 5. No post-graduation data for Cohort B students will be collected since this study will be completed. Overall, student attitude and SEL outcome data will be collected at up to 8-time points across each student's high school career (both Cohorts), and one-time point post-graduation (Cohort A). Students from both treatment and untreated control groups will have equal opportunities to receive and answer student questionnaires. CPS students are not permitted to receive incentives.

Student Interview and Observation. Outlier will conduct semi-structured interviews with seven students from each of the study's treatment groups. Students will be randomly selected and interviews will take place annually from January/February to March/April (Year 1 to 5) for an in-depth understanding of students' perceptions and experiences participating in The Model. We will interview each student for 45-minutes per year of their high school career to understand changes they may experience over time, oversampling in the event of attrition. Interviews will enhance questionnaire findings by providing rich data on both implementation (RQ 1), factors that affect implementation (RQ 2), and student perceptions of outcomes (RQ 3). Outlier will also collect observational data on each Model component (in class and out-of-class) to document first-hand student experience and inform our understandings of implementation (RQ 1). Outlier will conduct up to 24 observations (8 per each of the 3 schools) across grades. Observation protocols will be semi-structured and focus on the quality of implementation (defined by Lumity STEM Prep Logic Model). Preliminary observations will occur in Year 1 to shape protocol development. Protocols will be finalized, and observations will be conducted annually from January through April of Years 2, 3 and 4.

Teacher Questionnaire. Outlier will administer annual questionnaires to both treatment and untreated control group teachers in each school. Teacher questionnaires will primarily support understanding of Lumity implementation (RQ 1) and factors that affect implementation (RQ 2). These questionnaires will also supplement RQ 3 by assessing teacher perceptions of student outcomes (e.g. student interest in

STEM, student career goals). Questionnaires will be administered in January-April each year. The teacher questionnaire will be developed based on Outlier's validated teacher questionnaire measures from the aforementioned NSF-funded STEM School Study and the IES-funded USE Alliance (R305H160049) studies. These questionnaires have achieved peak validity and reliability in their measurement of implementation as well as teachers' ability beliefs and perceptions of student outcomes. Outlier and Lumity will work together to revise the questionnaires to ensure that their measures and associated items fully reflect the Lumity model, and appropriately measure teachers' experiences. Teachers will receive a $10 gift card for their participation each year. While deep examination of teacher outcomes is beyond the scope of this study, Outlier and Lumity can use teacher questionnaire data to set the stage for a mid-phase EIR proposal that more deeply examines teacher outcomes as a mediator to student outcomes. Teacher questionnaires and interviews will be valuable data for continuous improvement efforts of the Model.

Teacher and School Leader Interview. Outlier will conduct teacher interviews (randomly selecting 5 teachers from the treatment group in each school) annually from January/February to March/April (Year 1 to 5) to gather in-depth data on teachers' perceptions of the implementation of the Lumity model and experiences participating in this project, as well as perceptions of student outcomes. Concurrently, school leaders (1-2 per school) will be interviewed about their perceptions of the implementation and effects of The Model on teacher and school staff abilities and perceptions of student outcomes. Each interview will last approximately 45 minutes and will be guided by a semi-structured protocol. Participating teachers and school leaders will each receive a $15 gift card.

Lumity Staff Interview. Outlier will also conduct 5 interviews per year with Lumity staff and corporate partners. These interviews will be semi-structured and focus on understanding implementation (RQ 1) and external factors that affect implementation (RQ 2). They will help support Outlier and Lumity in continuous improvement.

Extant Administrative Data on Student Outcomes. CPS-provided administrative student-level data includes 9th grade on-track toward graduation (Allensworth & Easton, 2005), grades, GPA, SAT, truancy rates and discipline referrals. We will use historical district and school-level averages for 4 years prior to

The Model as baseline. We will request this set of administrative data annually for each cohort[4].

Data Analysis. Quantitative analyses will be conducted using SPSS or R, and except for HLM which will be conducted using HLM 7 Hierarchical Linear and Nonlinear Modeling (Raudenbush, Bryk, Cheong, Congdon, & Toit, 2011) software.

RQ 1 and RQ 2. Data sources: Teacher, school leader, and student questionnaires, teacher, school leader, and student interviews, and interviews with Lumity staff.

Year 1 to 5: Quantitative analysis. *Descriptive Analysis:* Descriptive statistics for questionnaire measures, including means, standard deviations, and Pearson bivariate correlations will be generated for all continuous variables, whereas group percentages and cell counts will be examined for categorical variables. *Psychometric Analysis:* All questionnaire analyses will begin by assessing the validity and reliability of all items in student questionnaire. As teacher questionnaires will be given to 36 teachers/year, psychometric analyses will focus on statistics appropriate for sample size (e.g. Cronbach's alpha.). Student questionnaires, which also provide critical data on student outcomes (RQ 3), will undergo best-practice psychometric testing. A series of confirmatory factor analyses (CFA) will be conducted to investigate whether items included in the questionnaires load on expected latent constructs and we will use multiple fit indices to evaluate the fit of The Model (e.g., Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and the Chi-square Ratio) (Hu and Bentler, 1999). Criteria normally used for a good fit of a model is CFI $\geq$ 0.95, RMSEA < 0.06, and 3.0 or greater for the Chi-square ratio. An acceptable fit of a model can be CFI $\geq$ 0.90, and RMSEA< 0.08 (Hu & Bentler, 1999; Kline, 2010). In addition, the internal consistency or homogeneity in items associated with the same construct will also be evaluated with Cronbach's (>0.7) and Zumbo's alpha (Caligiuri, Jacobs, & Farr, 2000, the latter is appropriate for ordinal data, Zumbo, Gadermann, & Zeisser, 2007). We will evaluate models to see if the initially hypothesized models show a good fit or acceptable fit and if

[4] Prior experiences across multiple federally-funded studies demonstrate that CPS administrative data acquisition can be a challenge, and although submitted in a timely way, data requests may not be attended to within project timelines. Thus, our research design allows for rigorous outcome analyses (meeting WWC standards) based on our own data collection, whether or not CPS administrative data access is granted. However, acquiring administrative data will be a priority for Outlier and Lumity. To best secure data in a timely fashion, Outlier and Lumity will begin legal data request processes upon funding and work closely with CPS contacts to expedite the process.

not, The Model will be revised and re-tested. *Hypothesis Testing:* In addition to standard descriptive analyses and teacher questionnaire data used for HLM-related analyses, we will use non-parametric statistics to analyze teacher data (e.g., *Mann–Whitney–Wilcoxon test*) to examine the effect of the Lumity model on teachers' responses between treatment and control groups. Longitudinal teacher data will be analyzed using the *Friedman test* to investigate changes in teachers' reports of implementation, as well as perceptions of student outcomes. We will also use crosstabs analysis with Chi-square tests to conduct item-level analysis.

RQ 3. Data sources: Student questionnaire, student interviews, extant administrative data as available

Year 1 (Cohort A): Quantitative Analysis. *Descriptive Analysis:* Same as described above.

Major Hypothesis Testing: Analysis of Covariance (ANCOVA) (Dimitrov & Rumrill Jr, 2003) will be used to examine if there are differences of students' attitudes, SEL, *students' truancy rates, discipline referrals, and academic achievement data* (*if accessed*) between treatment and untreated control groups, as well as across gender and ethnicity. This analysis will provide useful information for better implementing interventions, interpreting results, and generalizing findings for subsequent implementation. Multiple regression will also be conducted to investigate the relationship between students' attitudes (or SEL) between administrative data (if accessed).

Year 2 (Cohort A and B): Quantitative Analysis. In Year 2, Cohort B will join this study, and both quantitative and qualitative data will be collected and analyzed similar to Cohort A. *Hypotheses Testing:* Repeated measures ANOVA will be used to analyze questionnaire data for Cohort A. This analysis will explore changes in students' attitudes and SEL abilities measured from Year 1 to 2. ANCOVA will be adopted to analyze administrative data between different groups of students. ANOVA will be also used to analyze data collected in Year 2 for both Cohorts (A and B) to compare the project dosage (one year VS. two years) and to analyze differences in students' STEM attitudes, SEL skills, and administrative data between the two cohorts. Multiple regression will be conducted to investigate the relationship between students' attitudes, SEL and administrative data. Two-level HLM will also be conducted (Raudenbush & Bryk, 2002) (See *Appendix A* equational representation of these analyses.) Dependent variables in Level-1 HLM will be students' attitudes, SEL, and administrative data. Students' demographics (e.g., gender,

race/ethnicity, and socioeconomic status) will be added in Level-1 as a student-level variable while teacher variables will be included in HLM at Level-2.

Year 3 - 5 (Cohort A and B): Quantitative Analysis. Outlier will conduct three-level Hierarchical Linear Growth Curve Modeling (Raudenbush & Bryk, 2002) each year from Year 3 to 5 to investigate the growth rate of students' attitudes and SEL collected from questionnaires (Please see Appendix A for an equational representation of these analyses.) Students' attitudes or SEL will serve as dependent variables in Level-1, students' growth rate will be included in level-1 model, students' demographics will be added to Level-2, and teacher variables will be entered in Level-3. ANOVA will also be conducted to examine differences in post-graduation data collected in Year 5 between treatment and control groups and between students in different socio-demographic groups.

Qualitative Analysis. Outlier has extensive experience in using grounded-theory approach (Martin & Turner, 1986) to analyze qualitative data for both emergent (inductive) and hypothesized (deductive) themes. Grounded-theory will enable researchers to identify concepts that can be grouped into categories to develop a theory. Directed by grounded-theory, these qualitative data will be coded to address RQs 1-3. Analyses will focus on understanding the implementation of the Lumity model in and out of the classroom, how the Lumity model affects students' abilities and perceptions related to their STEM learning, and which Lumity model activities, or components, are perceived to be most associated with student outcomes. To ensure the reliability of the coding process, one third of the sample will be coded by two researchers. Qualitative data will be analyzed with MaxQDA software.

Communication and Continuous Improvement. At the forefront of Outlier's goals will be a focus on providing timely data to serve Lumity as a "critical friend." Outlier's extensive work in implementation research, evaluation, and strategic planning provides us with the tools to deliver data that supports the continuous improvement of the Lumity model. See *Continuous Improvement* and *Management* for details on roles and coordination. Outlier will continuously synthesize data to understand impact and drive an ultimately stronger Model that will set the groundwork for a more in-depth mid-stage study on more rigorous outcomes and sustainability/scale-up.

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