MITO EDITORIAL

Reflections on Collaboration, Communication, and Convergence

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Strategic models for

STEM education and research

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He holds a BS in Chemical Engineering from Stanford University, an MS in Environmental Policy Studies and a PhD in Environmental Science from NJIT, and a Masters of Education in Curriculum and Teaching focused in Science Education from Teachers College, Columbia University. He conducts extensive research in digital learning, curriculum, and instructional design and is currently piloting online converged course delivery methods.

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In this role, Cristo manages the logistics of research programs as well as pre and post-award actions for +100 active grants, overseeing the submission process of research proposals, serving as a liaison with the Office of Research, the College Dean, 7 departments, and over 110 faculty PIs. As of 2022, he has submitted over 1,400 proposals to federal, state nonprofit, and private sponsors requesting over $744M in total direct cost. He also has assisted in the process is setting up the 342 new awards for $78M in total direct cost.

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Mito Editorial
Editor & layout : Martin Van Houtte
General Coordination: Jimena Serret y Marcos Cabobianco
Coordination Assistant: Pedro Leonetti
Graphic Design: Fernando Alberto de Carabassa
Printed by: Help Goup SRL - www.hgprint.com.ar

León, Cristo
Reflections on Communication, Collaboration and Convergence : Strategic models for STEM education and research / Cristo León ; James Lipuma ; Víctor Hugo Guzmán Zarate. - 1a edición para el alumno - Ciudad Autónoma de Buenos Aires : Jimena Serret Iriart, 2023.
Libro digital, PDF
Archivo Digital: online
ISBN 978-987-88-8278-9

1. Educación. I. Lipuma, James. II. Guzmán Zarate, Víctor Hugo. III. Reflections on Communication, Collaboration and Convergence: Strategic models for STEM education and research.
CDD 371.9028

1st edition: march 2023

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To Cynthia for her wisdom and undying care.

To my wife Maria Lucero de la Rosa and to our children Juan Francisco Guzmán de la Rosa, Víctor Hugo Guzmán de la Rosa y Lucero del Carmen Guzmán de la Rosa

Strategy is not the consequence of planning, but the opposite:
it's the starting point.

Henry Mintzberg

Preface

By John Wolf, Ph.D.

Literacy in science, technology, engineering, and mathematics (STEM) is essential for full participation in the knowledge economy of the twenty-first century. Yet mastery of STEM domain content alone may not be fully sufficient to prepare today's students to become tomorrow's leaders. In addition to knowledge transfer—a task that presents numerous institutional and pedagogical challenges in and of itself—contemporary STEM education must also consider those characteristics that will best prepare students for enduring success, up to and including the point at which they graduate from students to become practitioners, regardless of the numerous fields across multidimensional industries in which that practice might occur (e.g., academia, government, industry, etc.).

The following collection of articles, based on the authors' primary empirical research, which, taken together, spans several years and numerous sponsored research endeavors, present frameworks for thinking about STEM knowledge transfer and student character building as well as practical suggestions for everyday praxis. There's no shortage of challenges and opportunities that await educators and students alike in this domain, and the ideas presented in this anthology comprise a thoughtful and nuanced ingress to a landscape, the pace of change of which by far outpaces the scholarship attempting to document and explain it. Indeed, this collection succeeds, in no small part, because it makes no effort to capture scholastically a moment in time, but rather it presents a comprehensive overview of systems and models for the ability to think contiguously and unabatedly about contemporary STEM education notwithstanding the ever-accelerating rate at which these changes seem to occur.

Key and common to the ideas and paradigmatic models presented throughout this book are notions related to collaboration and communication, the importance of which either one cannot be overstated. Wisely, the authors choose to adeptly synthesize these areas of praxis throughout the text rather than presenting ideas about them in isolation or without reminder of their necessary and inherent nexus. The case that collaboration and communication are fundamental for keeping pace with the constant cultural, pedagogical, and sociopolitical changes surrounding STEM literacy is made convincingly, and, furthermore, the authors invite readers to consider the implications of these tools for praxis and scholarship more broadly, even that which may at first seem beyond the boundaries of contemporary STEM education.

Dr. John Wolf.

Chapter 1. Introduction

Much of this work concerns learning and education systems especially related to Science, Technology, Engineering, and Math (STEM). The authors have a diverse background that overlaps in several areas of interest. However, each reader should be aware of some foundational concepts related to these areas. For this chapter, we begin with a brief and broad introduction to concepts of education and learning to set the stage for the research conducted over the previous five years by the authors.

1.1 Learning and your approach

One significant distinction that must be considered at the outset is your view of what it means to teach and how this is accomplished. For some, delivering material is teaching while for others teaching only occurs if the learner can access and master the content to be taught. Along these lines, some view learning as being accomplished through control of experiences designed to change the actions and mental processes of learners (Instruction-centered) while others see it as working to have the learner build new knowledge (learner-centered). Your views on these types of questions will fundamentally change the way you conceive of and develop the plan for the learning experience. Two of the major theories demonstrating this distinction are Behaviorism and Constructivism. The Behaviorists feel students or any learner can be trained through modeling behaviors and then following this with reinforcement tied to shown behaviors. Constructivists feel that knowledge is constructed in the minds of students and not transferred so the student must be the focus of the education, allowing each to experience learning in the way that best suits his or her own needs and interests. Be-

yond these general distinctions, there are subtle differences within these major theories that have been refined and adjusted over the last century. Today, many different names are used to describe the means that teachers use to present material to students and foster learning to achieve goals and attain learner mastery. Knowing the name of what the teacher does is not as important as seeing the distinctions between those things that are used to force an end goal or behavior versus those that are designed to allow the learner to grow guided by the teacher towards the end. Learning that is problem-based, inquiry-based, active, experiential, holistic, or emergent is more constructivist and student-centered. Learning that is goal driven, test-based, or has behavioral objectives tied to rewards is more of a behavioral learning environment. Other environments exist, such as an apprenticing or mentoring system that allows pupils to work with experts or homeschooling that delivers knowledge to students from parents through prepared materials and individual desires.

Learning takes many forms and there are many things that a student learns to do as he or she moves through the educational process. Generally, the purpose of education should be to prepare students to know what to expect as well as deal with the unexpected. At first, a child imitates the models that are shown and learn to memorize and repeat things. Directions are given and learning to understand and follow these instructions is an essential part of education. As time passes and experience is gained, learning moves to the knowledge that is internalized and thus known. This body of knowledge is added to as learning progresses so that skills are developed in the learner. Modeling continues as more complex processes are experienced and a depth and breadth of knowledge are developed. These two types of learning go hand in hand to help the student develop.

Eventually, the student needs to develop the ability to handle problems that have not been experienced. Education prepares students to figure out what to do when facing an unknown situation. Adaptability and the ability to solve problems are key to the future success of any student. This leads to the highest le-

vels of education in which a student seeks his or her own ends. If students are supported to make their own choices and lead themselves, education becomes self-directed toward their own goals. As this development takes place, questions of motivation and interest become more important since self-direction places the emphasis and path of learning more on the learner.

All of this can be summarized by the following four things:

- You are told what to do
- You know what to do
- You can figure out what to do
- You can lead yourself and others to what you want to do

As you work through these steps, one thing to mention is a major problem many students have that comes from earlier years of the educational process and life in general. This is the idea of preconceptions about things and the conflict that exists between common sense and accepted knowledge. Preexisting knowledge can be misunderstood or wrong. If these types of misconceptions are not highlighted and addressed, the student may compound these as new knowledge is associated with these incorrect ideas. Furthermore, some observations and common-sense understandings of the world do not agree with what is generally accepted as correct by scholarly experts. As a result, it is necessary to be willing to question what you know and examine new knowledge. Knowing you might not always be correct allows for the potential to change what you know in light of new ideas. Having a clear picture of learners' prior knowledge is essential for effective instruction.

1.2 Learning and working styles

Knowledge acquisition relates to a person's learning style. Learning styles are descriptions of the tendencies you show concerning how information is best gathered and remembered by a student and therefore how learning is best accomplished.

There are many models and theories of learning styles but most identify three major distinctions—visual, auditory, and kinesthetic/tactile. Though every learner may not fall into one of these exclusively and each can be broken into subsets, the three major divisions are useful at this point to help you become more aware of how you approach instruction.

Visual learners prefer to have things shown or written out. This type of learner usually prefers pictures, written text, or both. Writing items down and reviewing material visually reinforces learning for these types of learners. The auditory learner prefers to have things presented orally or through discussion. This type of learner often learns better by repeating aloud and discussing concepts or even by using audiotapes and e-books. Finally, the kinesthetic/tactile learner prefers to be involved in the learning process through active learning, demonstrations, and hands-on activity in the class. Many times asking questions and engaging in laboratory or multimedia learning tools assists students to comprehend learning. Often, visits to locations related to the topic being studied, such as parks, historical sites, museums, learning centers, etc., or having actual examples of the subject is useful for this type of learner.

Terms related to learning such as active versus passive; or top-down/global versus bottom-up/detail learning, are used to describe how people build understanding based on knowledge. Some people are even multimodal or can change styles depending on the subject, environment, age, or many other aspects.

It is useful to understand how learning styles affect you and fit better with how people learn and interact with new material. These natural tendencies influence the way individuals process information and thus collaborate. As we discuss interactions both tied to education and more broadly as part of inter-disciplinary collaboration, these foundational ideas underpin the approaches that we use and developed. The more diverse a group the more important it is to be aware of the diversity of styles, backgrounds and approaches to the problem in the given scenario.

1.3 General Principles

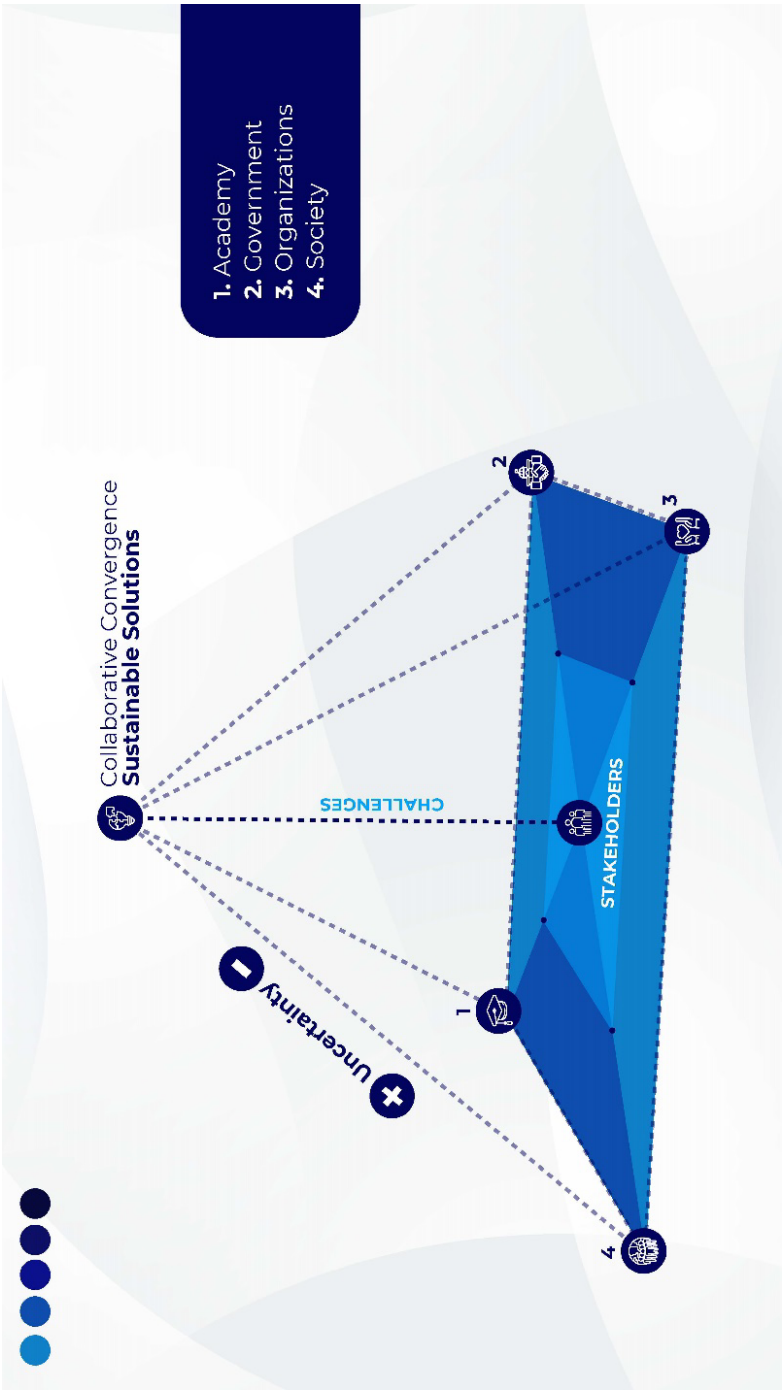
Before going into our published works and the concepts and models in this book, we wanted to be explicit about the areas of our work that come together here. As we work to develop a clear understanding of communication and collaboration in a trans-disciplinary space, aspects of our interests and research pursuits are emphasized less. In the context of this book, we have the following areas that inform our work and provide a space for us to conduct research and perform the needed steps of design and development.

- Modes of instruction from synchronous (in-person) to fully asynchronous online
- Research approaches, outreach, and community engagement
- STEM Education and practice
- Strategic Planning

Beyond this common space for action and research, a key factor that allows us to collaborate effectively is a shared 'Worldview' and guiding principles, By embracing an intercultural, diverse, inclusive, and open-minded worldview, the work described here was made possible.

As we began to work together, we discover that our approaches to problems and doing research were based on Critical Theory and postmodernism. We found ourselves using a multi-sector, collaborative, and co-design approach to problems as we tackled large-scale, complex issues facing society. As we engaged in research, we found it necessary to work at the interfaces of disciplines and even sectors of society leading us to explore Inter- or Trans-Disciplinary levels. Thus, we find the need to understand and explicated the "Collaborative Convergence Approach" (CCA) to research (see Figure 1). This CCA is based on several established theories:

Figure 1. Collaborative Convergence Pyramid

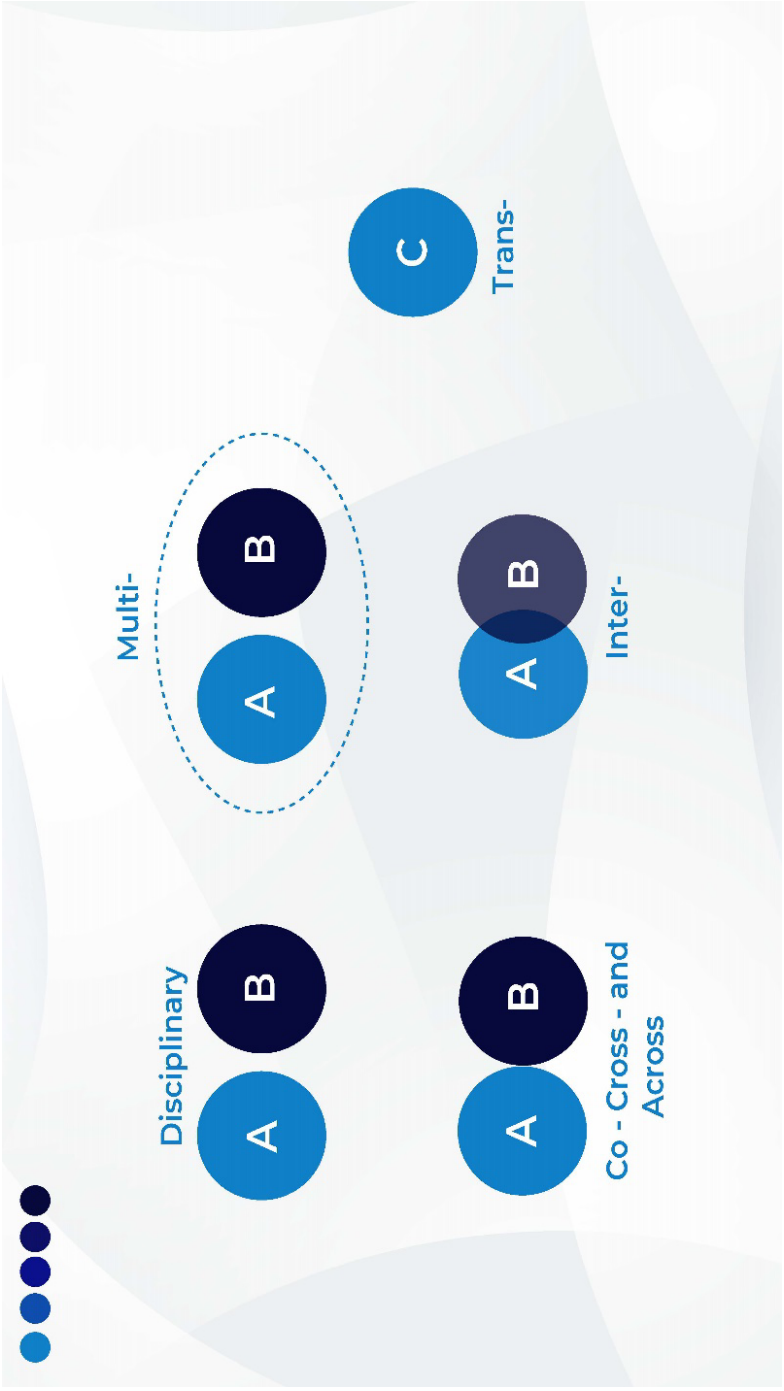


- "Constructivist Grounded Theory (CGT)" (Bryant & Charmaz, 2010; Charmaz, 2006; Corbin & Strauss, 1990; Glaser & Strauss, 1967; Hafer, 2021),
- "*Critical Theory (CT)*" (Bohman, 2003; Bohman et al., 2021; Zanetti, 1997),
- "*Diffusion of Innovation Theory (DIT)*" (Halton et al., 2021; Moore, 2014; Rogers, 2003),
- "*Intercultural Competence (IC)*" (Deardorff, 2009; Dodd, 2017; Leeds-Hurwitz, 2017), and
- "*Theory of Interactive Team Cognition (TITC)*" (Abramo et al., 2017; Fiore, 2008; Hall et al., 2019; Hofstede et al., 2010; Kozlowski & Ilgen, 2006; Stokols et al., 2008).

Other influential concepts that have not fully developed into a theory but that relate to the work we do include: Networks and Communities of Practice, Team Science, and Convergence of Knowledge, Technology, and Society (CKTS). Throughout the book, we use the word "Educator" but it can be easily replaced by the words: Teacher, Professor, Administrator, Superintendent, or even parent during COVID-19. The word Educator is meant to be used as a catch-all phrase that includes anyone who has overseen education.

Throughout the text, you will find the word "Discipline" applied in different scenarios. The authors want to note that the concept of a discipline encompasses more than just a narrowly defined academic subject or group of related areas of investigation. It is used here more broadly as the field of study or an area of focus (see Figure 2).

Figure 2. Disciplinary Spaces



Chapter 2. Laying the groundwork (Abstracts)

As the authors developed their collaborative research work, the overlap in online education, interdisciplinary communication, and STEM outreach produced several published research articles. This section provides the abstracts of those articles along with a link so readers can read the full text if desired. These papers serve as a background to the material presented in the upcoming chapters as the core principles of collaborative communication and research approaches are explored and explained.

2.1 Mode Matters

One of the initial points where our research intersected pertained to the methods of instruction. For many years, the research discussion examined how instruction was delivered with a simple view of two states—in-person or remote. As technology advanced and research continued examining the factors related to the variety of options or 'modes' of instructional delivery, more factors emerged. These included synchronous vs. asynchronous, on-ground vs. online, Face-to-face vs. at a distance and managed vs. self-paced. Each of these different modes has unique factors that require adjustments to methods of instruction, teaching style, and at times, philosophy of education. These factors occurred during the COVID-19 crisis, but NJIT has been researching this topic since 2013.

Title: Exploring the Context of Converged Learning: a case study in a polytechnic university

Abstract: New Jersey Institute of Technology (NJIT), a four-year polytechnic R01 research university in the United States utilized a participatory strategic planning process to implement an innovative approach to the modes of delivery for instruction that exist between face-to-face and online instruction. NJIT defines the spectrum of integration of online and on-ground instruction as Converged Education. This spectrum allows students to either participate face-to-face, join remotely through real-time video conferencing technology synchronously, or watch classroom instruction asynchronously.

The article opens with a general background of NJIT's approach to the new idea of converged instructional delivery. It provides a brief history, context, and explanation of its interdisciplinary participatory strategic planning process. Then the paper describes the process of pilot testing that was conducted to determine how best to adopt the new modes of instruction across all disciplines. Next, the process for defining and clarifying the terms and conceptions of the various modes to be adopted is presented. After this, the paper discusses the impact of the shift from Web 1.0 to web 6.0 and how the different departments and sectors of NJIT worked on strategic planning together. Finally, the resulting implementation of the new policy and its reflection on course offerings is shown and discussed. (Lipuma & Leon, 2022)

Source: Lipuma, J., & Leon, C. (2022). Exploring the Context of Converged Learning: A case study in a polytechnic university [Review of *Exploring the Context of Converged Learning: A case study in a polytechnic university*, by B. Bukiet]. *The Journal on Systemics, Cybernetics, and Informatics*, 20 (1), 102–121. https://doi.org/10.54808/JSCI.20.01

2.2 Scenario Matters

As our collaboration continued to develop, another key synergy became apparent. In the diverse areas of study and teaching activities, the need for a common language was identified. Whether as part of teaching undergraduates, managing research projects, or conducting research on STEM Education, the idea of scenario specification became an essential concept. For our work, we defined this concept as the description of the Goal, Target, and Situation related to the domain of discussion. Each of these major components has several elements that help delineate the communication and collaboration that occurs. This was explored in our research project that brought a range of New Jersey K-12 educators together to share out their experiences and solutions resulting from the shift to online education during COVID.

Title: Scenario specification structuring effective collaborative communication

Abstract: The support from the Howmet Aerospace Foundation Grant No. 223990 led to the development of digital resources for hands-on STEM that would be useful for student learning in an online world, compiled as “Tools for Teachers a STEM for Success Guide”. 100 teachers and over 500 students from 20 schools participated in the project. This article describes the project activities, results and lessons learned that allowed them to pivot from a face-to-face model to an online model as well as the benefits that a co-design strategy brings to broaden participation and inclusion in multi-stakeholder collaborative projects. (Lipuma et al., 2022)

Source: Lipuma, J., Yañez Leon, C. E., & Patel, K. (2022). Scenario Specification Structuring Effective Collaborative Communication. In *Proceedings of the 16th International Multi-Conference on Society, Cybernetics and Informatics: IMSCI 2022* 51–56. https://doi.org/10.54808/IMSCI2022.01.51

2.3 Language matters

Our work involved individuals and organizations from diverse cultures, backgrounds, and community interests. As we worked together with this diverse collection of researchers and stakeholders, it became clear that common language must mean more than spoken words or translated documents. Finding commonality through negotiation of understanding is vital to effective trans-disciplinary collaboration. The different conceptions of language and the concept of idiolect provide a means for better more effective communication.

Title: Collaborative Convergence: finding the language for Trans-Disciplinary Communication to occur

Abstract: The proper study of communication from existing models opens the doors to scientific research that allows exploring language and coding as an integral part of effective communication to generate new models that include Trans-Disciplinary Collaboration. The authors analyze the factors of communication to describe the application of Trans-Disciplinary Communication.

This paper aims to define the communication processes and their relationship with language, considering their impact on Trans-Disciplinary Collaboration for innovation.

After conducting a systematic literature review the article explored the concepts of communication, functions, language, and Trans-Disciplinary Communication. This led to its application in the convergence research approach as presented in the Collaborative Convergence Pyramid. (Leon & Lipuma, 2022)

Source: Leon, C., & Lipuma, J. (2022). Collaborative Convergence: Finding the Language for Trans-Disciplinary Communication to Occur (Invited Paper). *WMSCI 2022*, 147–150. https://doi.org/10.54808/WMSCI2022.01.147

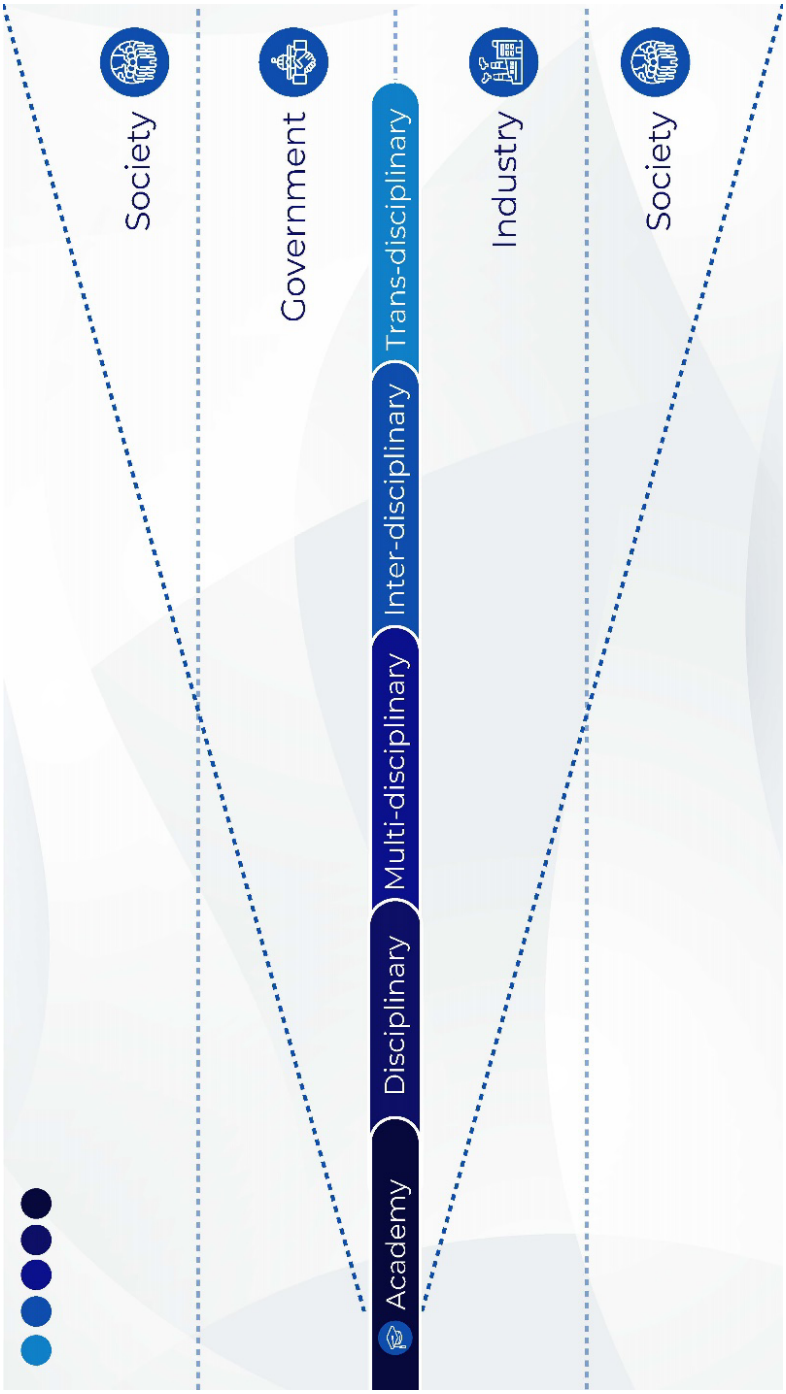
2.4 Collaboration matters

As the scope and scale of the organizations we worked with grew, the need for collaboration was essential. Moreover, understanding and finding shared visions and missions was a key way of integrating our actions. Our research into effective collaboration for research at an inter- and trans-disciplinary level led to our Collaborative Convergence approach. Collaboration builds from a lone individual working locked away and isolated so knowledge is hoarded. As more than one individual begins to cooperate and share, we move towards collaboration. By communicating and exchanging knowledge we move away from an individual approach but may yet not be collaborative. The shift comes when together, the two individuals attain more than separately. This first level of collaboration is essential to society's innovation on a large scale. Next, however, organizational collaboration can occur between organizations built up by those individuals. This is much more complex but still essential to organizational development, innovation, and social change. Finally, at the largest scale, collaboration occurs at the level of systems so entire disciplines or sectors of society can collaborate and magnify individual action to attain synergy that yields a sum much greater than any of its parts (see Figure 3).

Title: Collaborating Toward Convergence Efforts for K-20 STEM Education

Abstract: The paper examines the use of NSF's Collaborative Infrastructure and the Convergence Research approach for complex social innovation challenges used by the authors in their NSF INCLUDES project (#1744490). The paper clarified terminologies related to Convergence Research for multi-, co-inter-, and trans-disciplinary. This paper defines and describes collaborative research at each of these interfaces. Then it discussed key factors for engaging in collaborative partnerships as individuals, with teams, and as organizations. Then, it presented concepts tied to individual factors for engagement with the attitude, investment, motivation, and scenario analysis me-

Figure 3. Academy to Society continuum



thod. Next, by drawing on business and management research, the Availability, Interest, and Knowledge methodology provided a simple way to identify the alignment of the vision, mission, and theory of change by understanding the why, what, and how of your actions. Following this, the authors integrated the concepts of strategic planning and logic models with the Universal Model of Strategic Planning. The authors discuss the double diamond model to represent the complex web of partnerships and the framework developed for communication and collaboration amongst stakeholders. The result is the Collaborative Convergence Pyramid framework for negotiating understanding within a new common space being generated together. Finally, the work concluded with a discussion of the vital roles collaborative infrastructure and strategic planning played in facilitating the Convergence Research approach with a multi-stakeholder coalition. (Lipuma & Yáñez León, 2022)

Source: Lipuma, J., & Yáñez León, C. E. (2022). Collaborating Toward Convergence Efforts for K-20 STEM Education [Review of *Collaborating Toward Convergence Efforts for K-20 STEM Education*, by B. Bukiet, S. Pal, & J. Wolf]. *The Journal on Systemics, Cybernetics, and Informatics, 20*(1), 351–389. https://doi.org/10.54808/JSCI.20.01

2.5 Why this does matter

For our work, the main purpose is to generate positive change and support our community members, colleagues, and stakeholders. At the heart of this is working to solve large social problems that require the collaboration of various individuals, organizations, and systems to make change happen.

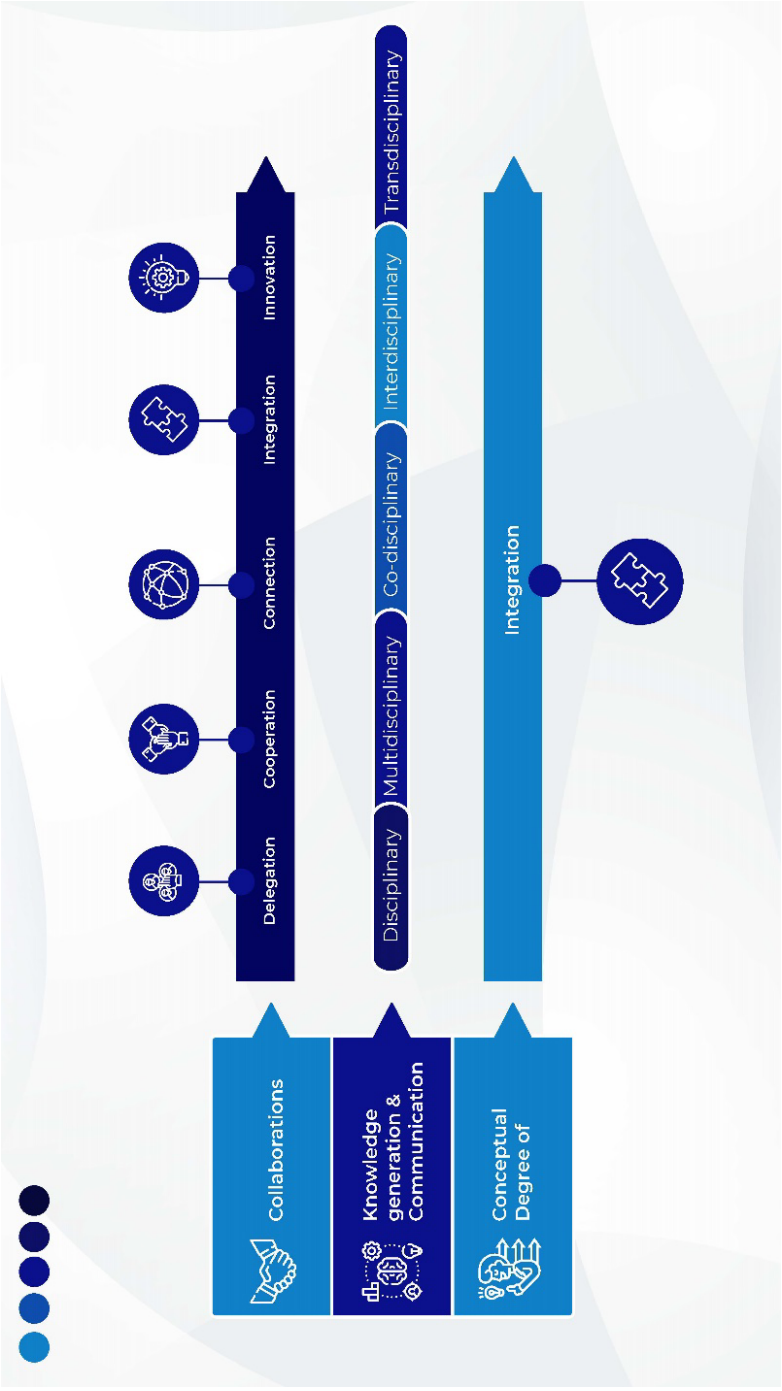
The definition of collective impact is “the commitment of a group of important actors from different sectors to a common agenda for solving a specific social problem at scale” (Hanleybrown & Splansky Juster, 2021). In our view, the five conditions of collective impact outlined in the initial 2011 Stanford Social Innovation Review article—common agenda, shared measure-

ment, mutually reinforcing activities, continuous communication, and backbone support—still hold.

Beyond this, the National Science Foundation (NSF) has promoted the collaborative infrastructure designed as part of the INCLUDES program to broaden participation in STEM by women, and other traditionally under-represented groups (TUGs). In the Report the Nation II NSF states that the infrastructure "is designed to foster collaboration by emphasizing five design elements of collaborative infrastructure: Shared Vision, Partnerships, Goals and Metrics, Leadership and Communication, and Expansion, Sustainability, and Scale" (2020).

Our particular area of focus deals with increasing and broadening participation in STEM across the PreK-20 continuum. Our work leverages expertise and experience in STEM education, digital learning, communication, and collaboration. We bring together a wide range of diverse individuals to create a multi-sector trans-disciplinary research community that can understand and act to make the changes needed. Moreover, with our partners, we seek to co-design solutions that can be enacted locally. These community actions can be shared and refined to have an impact at the regional level hoping to scale up to the global level in society. It is through this collaborative planning, research, and action we see great potential for success for everyone through STEM (see figure 4).

Figure 4. Knowledge Generation & Communication continuum (KGCC)



Chapter 3. Collaboration and Strategic planning

To help understand how our work comes together and is applied, this chapter shares some of the basics of collaboration and planning. We work with others to determine our shared vision, developed collaboration, and co-design working solutions. One such collaborative endeavor involved the Rutgers University Junior Science and Humanities Symposium. The Principal Investigator, Dr. Jean Patrick Antione, Associate Dean for Rutgers College of Engineering saw the need to reduce costs while reaching more students and engaging more judges from the public and private sectors. Faced with this situation, this essay explores an alternative solution that integrates the dimensions of strategic planning, logic models, and the theory of change to create an innovative model of planning with a focus on collaborative infrastructure called the Universal Strategic Planning Model (USP).

The chapter presents an analysis of strategic planning approaches and their limitations followed by a discussion on logic models and the theory of change. Next USP model and its uses are described. Finally, the results were examined to discuss how the USP model allowed the committee to co-design the new vision of the program as well as implement and optimize the program elements to improve the JSHS scale in the challenging time of COVID-19.

3.1 Scenario and Collaboration

Scenario describes the parameters and chain of events that leads to a specific coming together of individuals and organizations. Defining a scenario is useful when planning strategies,

understanding interactions, and impacts at the moment as well as when conducting after-action reports. It includes three categories: your goal, the target audience, and the situation in which the interaction occurs. Each of these components contains other elements to be considered by leaders as they plan and act. Communication and collaboration depend on these factors to specify the moment of interaction so that participants can be prepared and have the proper strategies to be most effective.

When examining the three phases of the "Prepare, perform, publish (P3) model" (Lipuma & Yáñez León, 2020) or any action for that matter, determining and delineating the elements of the scenario will be useful. Often, the planning phase will require multiple scenarios to be developed while during the moment of interaction; the planned scenarios are adjusted so needed supports can be leveraged to increase effectiveness. Scenarios are a major part of strategic planning and success across a wide range of disciplines and environments.

> Scenario planning has been defined in several ways. Michael Porter (1985) defined scenarios as "an internally consistent view of what the future might turn out to be—not a forecast, but one possible future outcome". Schwartz (1991) defined scenarios as "a tool for ordering one's perceptions about alternative future environments in which one's decisions might be played out". Ringland (1998) defined scenario planning as "that part of strategic planning which relates to the tools and technologies for managing the uncertainties of the future". Shoemaker (1995) offers, "a disciplined methodology for imagining possible futures in which organizational decisions may be played out" as a definition for scenario planning. (Chermack et al., 2001, p. 8)

3.1.1 Scenario components

There are three components examined in a scenario: Goal, Target, and Situation. If the sender can see the causal chain of events and the parameters tied to it, the participants can specify and so better understand the factors that influence and impact those involved. He or she will be able to identify the goal and so

set objectives to attain it, outcomes that are sought related to it, and the things that demonstrate their attainment. Similarly, the aspects of the identified target can be specified. At times, the target is chosen; in others, it emerges from the scenario. The more information about the target audience that can be gathered and specified, the more effective the scenario can be acted upon. Knowing about the demographics and other information on the target helps develop a profile for the target. In addition, determining the target's prior knowledge of the moment of interaction and familiarity with the content is important for refining the content. Beyond these informational items, determining the target's expectations and way of judging communication will provide a great deal of insight into the scenario and increase the overall effectiveness of leaders and speakers. The third component is the situation that examines the factors of the moment of interaction. The conditions are the physical location and related factors, the circumstances describe the paths that each participant followed to arrive at the situation in the prescribed scenario. Lastly, context looks at the larger concerns that surround two or more of the participants and the impacts that the conditions and circumstances might have on them as they interact within the moment of the scenario.

3.1.2 Elements of Scenario components

The table below contains the components of the Scenario along with each of their elements. Links are provided afterward to help expand some of these ideas related to these elements.

Table 1. Matrix GTS

Goal	Target	Situation
Objectives	Audience Analysis	Conditions
Outcomes	Prior knowledge	Circumstance
Deliverables	Expectation and Metrics	Context

3.2 USP Model Rationale

Having the expertise to apply a model or construct an intellectual framework or project management structure does not guarantee that the scenario will support it. The USP provides a means of structuring a set of steps with markers to delineate aspects of the scenario. In addition, the USP help align the differing levels of knowledge and engagement for different participants and partners. In the example provided by JSHS, NJIT CLEAR had implemented the USP in several projects (FRS-NJ, STEAM Tank, Life, and STEM for Success). That experience with the application of the model for collaborative engagement and project management leverages the expertise of the researcher. The successful implementation and outcome demonstrate quantitatively that the virtualization of the components of JSHS facilitated by the USP was successful. The qualitative discussions and feedback from the participants and continued use reflect positively on the ability of the USP to provide the needed analytical framework to both guide development and identify gaps for program planning and improvement.

As director of CLEAR and part of the JSHS executive planning committee, Dr. Lipuma accessed his experience in building successful programs and virtualizing instructional materials both for use in class and co-curricular K-12 environments. The objective of the work was to develop a coherent plan that aligned with the existing plans of Rutgers JSHS that would attain the integration of online tools and virtualized programs.

The program was highly successful under Dean Antione's guidance. Our objective was not to overtake the program or change it but help realize the collective vision of the committee members to attain the goal of larger numbers for lower costs. To that end, the USP model was applied.

The objective of this article is to provide a real-world scenario serving as an example of the USP model implementation. The USP provided a clear framework to analyze existing programmatic elements leading to the clear identification and communi-

cation of a shared vision. Then, in response to evolving desires for expansion, and sustainability as well as response to changing scenarios, the USP allowed for continuous planning and improvement to support shared goal settings with common metrics as well as implementation and optimization of program elements to improve JSHS scale in the challenging time of COVID-19.

3.3 Methodology

Socio-critical with a Mixed Method Approach: the authors seek to understand the reality of the schools and teachers with a co-design approach to integrate theory and practice. An exploratory study of the Rutgers JSHS status quo.

3.3.1 Professional Participants

PI. Jean Patrick Antione. Rutgers Dean, College of Engineering. Runs JSHS and recruits members of the executive planning committee. Committee members include individuals from NJIT-CLEAR, Picatinny Arsenal, NJ HS Schools, and Corporate/ nonprofit representatives. Main participants: Students. Additional Supporters: JSHS participants, Educator guides and facilitators, Research mentors from Universities, Government, and the Private sector, Judges- apply a national rubric to give feedback, tutor, and then finally rate student work, Other affiliates for expert presentations and enrichment at culminating seminar events.

3.3.2 Literature Review

The authors develop the ideas found in the review of the existing literature regarding strategic planning as well as decision and aggregation levels, integrating them with logic models (David, 2011; Frey, 2018c; Kellogg Foundation, 2004; Posse Fregoso, 2000; Valdés Hernández, 2009); to generate a holistic planning tool, which they call the Universal Strategic Planning Model (USP Model), applicable mainly to the field of academic research, based on the particular characteristics of the context where the

project of research, elaborated based on three fundamental concepts of strategic planning: the administration of academic research, the theory of change and project management.

3.4 Development

Some of the advantages of the "Systemic Approach" are: It bases the analysis, has global perception, and manages competitive intelligence among many others (Valdés Hernández, 2009). Its main limitations are: It causes indecision, it does not promote emotional intelligence, and it does not consider the advantages of the quantitative or mixed approach (Kogan Schmukler, 2017). These characteristics allow him to have a wide circle of influence in various sectors of society but limit him when trying to solve complex problems. In the operational field where problems can be considered constantly changing, complicated, and of social impact, the disadvantages of the systemic approach prevent it from achieving collaboration between the multiple levels of the system and the different needs of each group. Valdés Hernández provides a fundamental concept of the systemic approach by pointing out that “the organization is interrelated with another macro system called the environment and that it is everything that surrounds it and does not control it” (2014), so it is necessary to develop “transdisciplinary competencies” (Risopoulos-Pichler et al., 2020) that allow us to integrate the various interest groups in a common goal.

3.4.1 Strategic Planning

Fundamentally, strategic planning has two dimensions: "Strategic formulation and strategic implementation" (Garrido Buj, 2003; Lema, 2004). There is a moment before strategic planning where the analysis is proposed before proceeding to the design, followed by a measurement of results based on the control indicators that will allow us to generate the strategic review. While these dimensions are common to project managers, they may be unknown to academic researchers.

3.4.2 Decision and aggregation levels

In the context of organizational planning (Acle Tomasini, 1990; Cuero Osorio et al., 2007; Otero Iglesias et al., 2004), the decision levels Directors (D), Higher management (HM), Managerial level (ML), and Operative Level (OL) presented in Table 1 determine which area will be in charge of proposing the plan (D) and its programs, (HM), who will manage the project (ML), and who will be in charged with executing the initiatives (OL) composed of activities and tasks (Montes De Oca Aviña, 2018). Each level has a different influence on the decisions that will need to be implemented and/or adjusted (see Table 2).

Table 2. Decision and aggregation levels in the organization

Decision and aggregation levels in the organization		
Directors (D)	Vision & mission	Plan
Higher management (HM)	Strategic	Program
Managerial level (ML)	Tactical	Projects
Operative Level (OL)	Operative	Initiatives: Activities and Tasks[1]

Personal elaboration based on Planeación estratégica con enfoque sistémico *(Valdés Hernández, 2014).*

3.4.3 Logic Models and Theory of Change

In essence, the logic models are based on two general axes: The planned work and the expected results. Following closely the dimensions of the theory of change: assumptions and external factors. Logic models can be used as planning and/or evaluation

[1] Commonly these three words: "initiatives, activities and tasks", are used interchangeably depending on the context, and are generally referred to as activities. However, in the context of strategic planning, initiatives encompass activities and tasks.

tools. The authors agree with the ideas of Shannon and Weaver (1963) and adopt the Kellogg Foundation's definition of logic models: "The term logic model is frequently used interchangeably with the term program theory in the evaluation field. Logic models can alternatively be referred to as theory because they describe how a program works and to what end" (2004, p. 2).

The fundamental parts that make up the logic model: Production, results, impact, resources, and activities. They can be generally understood from the organization's approach and the research approach, however, the superposition of the elements often generates confusion since their definitions vary in the Particular and the Specific levels, as well as in the contexts of planning, evaluation, and the results report. By adding the dimensions of control, analysis, and strategic design (Amorocho et al., 2009; Lema, 2004; Mintzberg et al., 1997) the feedback loop can be closed, allowing us to integrate strategic planning and evaluation into the life of the program.

3.4.4 USP model

In academic research, it is often necessary to collaborate with different organizations and associations, both public and private. There are several models and methodologies (Basarab Nicolescu, 1996; Ravitch & Mittenfelner Carl, 2020; Scholz, 2020), for the development of disciplinary and multidisciplinary research that will generate convergent research (National Science Foundation, 2018). However, when the researcher wishes to participate in research programs such as NSF INCLUDES (NSF, 2017) or those that are based on collaborative infrastructure: “NSF's 10 Big Ideas” (National Science Foundation, 2016), the researcher discovers that developing inter-disciplinary, trans-disciplinary, and/or convergent programs requires planning with greater emphasis on strategic planning. It can be challenging to integrate multiple organizations, especially when some may require a deeper understanding of fundamental research methodologies and systemic problem-solving approaches, which are constrained by their limitations.

The USP Model was born from the primary need to create a tool that allows addressing strategic planning focused on the collaborative infrastructure, thus taking advantage of the knowledge base of those involved, which results in the enrichment and strengthening of the project. The secondary need was to support the various interest groups in the ecosystem ofsubsidized research at the "New Jersey Institute of Technology" (NJIT, 2021), a Polytechnic University of Higher Education in the United States, where the two authors work. The dimensions of the USP Model presented in Table 2 are complemented by the decision and aggregation levels previously exposed in Table 3 (see Table 3).

Table 3. Decision levels and dimensions of the USP model

Decision and aggregation levels			**Dimensions of the USP Model**
(D) Rutgers	Vision & mission	Plan	I. Pre-planning
(HM) CLEAR	Strategic	Program	II. Strategic planning
(ML) Committee	Tactical	Projects	III. Implementation
(OL) PI	Operative	Initiatives	IV. Follow-up

Personal elaboration (based on Valdés Hernández, 2014).

3.4.5 How the foundation of the USP Model is created

Usually, the researcher has greater clarity about the dimension of the implementation and can identify its components: 1. Products, 2. Results and 3. Impact. However, integrating the components of the remaining dimensions: 4. Strategic Design, 5. Strategic Analysis, and 6. Control tends to be outside their area of expertise. The first step to developing the USP Model in an academic investigation is to accurately describe each of the

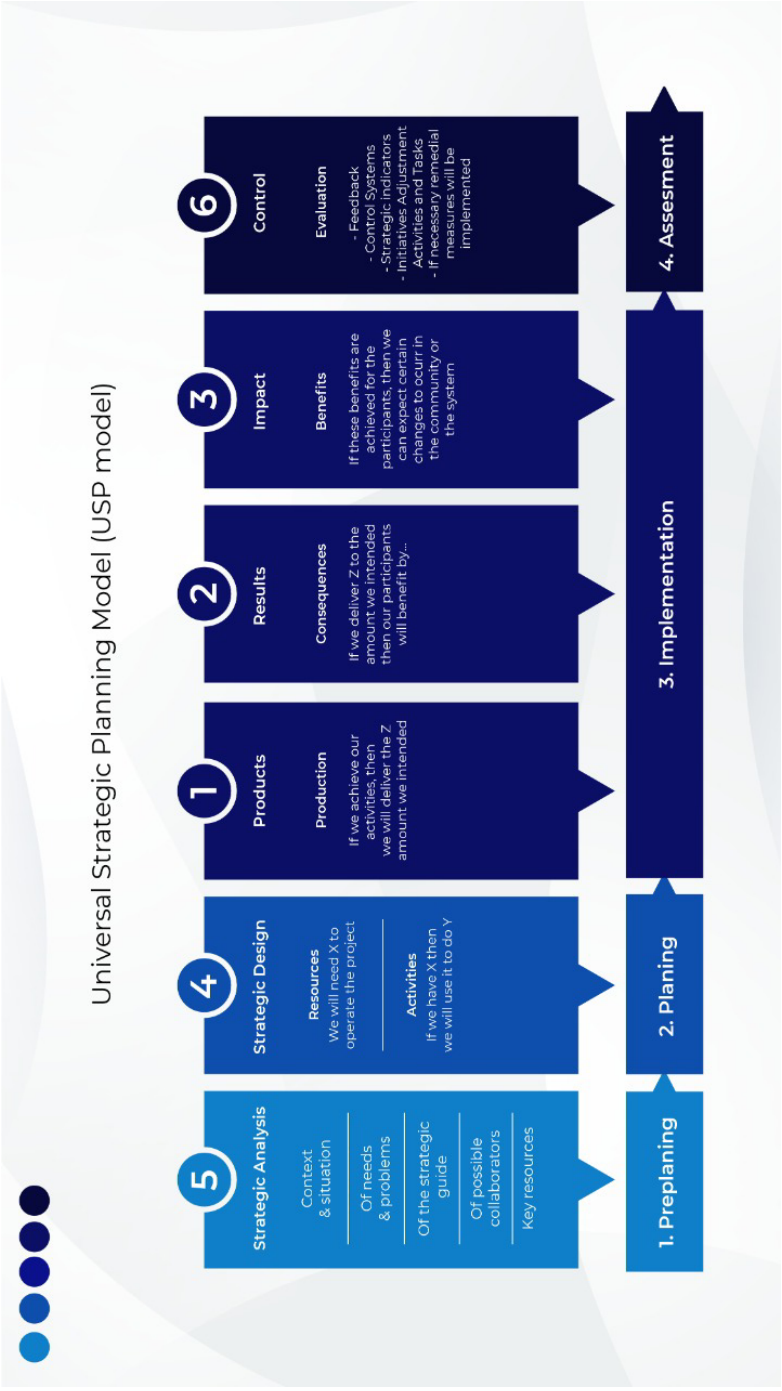
six components, in the order that the researcher or the collaborative team deems appropriate. Once the components have been focused with clarity and precision, the next step is to locate them in the corresponding dimensions (I to IV), to form the diagram presented in figure 5 (below), thus concluding the logical foundation of the model.

3.4.6 Description of model dimensions

I. *Pre-planning*: The dimension of Strategic Analysis (Hax & Majluf, 1995) requires a Strategy as well as a Strategic Guide (Lema, 2004), where the vision, essential ideology, methods, and, if possible, the Just Cause (Sinek, 2019), it is necessary, as well, the delineation of the situation (Mintzberg et al., 1997). In the case of academic research, the pre-planning stage includes the search for financing instruments, the analysis of the context of the social problem, and the articulation of the vision of the program with the vision of the institution, and with the personal vision. Pre-planning is commonly overlooked, but it is at this stage that a recount of the ideas, resources, techniques, and strategies that will make the investigation possible is made. This is the moment in which possible collaborators are identified; they will give greater depth to the plan, for example, relationships with evaluators, colleagues from other institutions, or relationships with intermediate and higher educational institutions, among many others. The objective of this dimension is to determine the initial situation, the existing needs, the selected problems, and the possible resources at our disposal. When the collaborators consider that success is possible, they can continue with the Planning dimension of the project. It is important to highlight that within the Strategic Analysis, the following items are examined: the context and the situation, the needs and problems, the strategic guide, the collaborators, and the key resources at our disposal.

II. *Planning*: It is the dimension in which, after identifying the situation and needs, the general plan on which the project design is developed. It can also be referred to as work planning. In this dimension, the participants will describe the resources

Figure 5. Universal Strategic Planning Model



needed to implement the program and what they intend to do. Within this dimension, the following items are considered: the strategic design, the available resources, and the activities to be carried out. It begins by identifying and/or clearly describing the "X" resources that we will need to operate the project. The Initiatives: Activities and Tasks continue to be broken down precisely, in such a way that, if we have "X" then we will use them to do "Y".

III. *Implementation*: The dimension in which the desired outcomes are generated is crucial. Hence, it's vital to acknowledge the existence of two scenarios: the ideal implementation, where the intended achievements are articulated and visualized on paper, and the converse of the actual performance when the project is executed. An adequate description of the products and expected results will make it easier for us to carry out production and determine its possible consequences.

In basic and exploratory research, this distinction is difficult to make, measurable tangibles or in some cases preliminary data are not yet available, however, talking about the ideal implementation is easier when it is described as the performance of the activities exposed. The planning will allow us to deliver the quantity/number of products that we wish to offer to the project participants, so that, consequently, we will be able to obtain results, which must be measurable. These results are what will be observed in the actual implementation.

The Implementation contemplates the products or the production, the results, the consequences, and the impacts. We will maintain a logical reasoning chain as we describe the products, including production or inputs. Then, if we can execute our initiatives, which may involve various activities or tasks, we can deliver the desired quantity of "Z" to the participants. It is in this section where researchers begin to have difficulty in articulating the prediction of the objectives since in several cases the investigation may be exploratory or not have enough preliminary data to identify the possible changes resulting from the intervention. The results or the consequences of the process lead us to say that: "if we deliver 'Z', that is, the amount we intended, then our participants will benefit by... (a predicted goal is added)". In this

part, it is important to find a clear base or metrics against which to compare the desired results to offer a more precise idea of what you are trying to achieve. Defining the impact may appear to be a straightforward step, but it is also the most challenging. First, the chain of reasoning is concluded if the benefits for the participants are achieved. Then, we can expect specific positive changes to occur in the community, society, or the system.This is the last step in the implementation.

IV. *Follow-up*: The last dimension corresponds to Follow-up; here are the control systems, the evaluation, the feedback, the strategic indicators, the adjustment of the initiatives, and, if necessary, the remedial measures that will be implemented. It is very important to consider that the feedback is external, neutral, and impartial. If it is not possible to hire an external evaluator, an internal evaluator can be used, but objectivity may be compromised in the second case. The key element in this dimension of control involves specifying the control and monitoring systems, outlining the evaluation process, defining the feedback channels, and determining the strategic indicators. These indicators usually follow the structure of an annual report and are essential in most research programs. Communication channels are established with collaborators and evaluators, as well as with the community and participants.

3.4.7 Diagram of the USP Model.

The logical argument check is structured according to each of the four dimensions in the order presented at the bottom of the diagram (see figure 5, above); following the reasoning premise "If X... then Y...", thus consolidating the research project.

The proposal of the USP Model focused on collaborative infrastructure integrates the dimensions of the Theory of Change, grouping all the previously stated definitions to generate a universal strategic planning tool based on the particular characteristics of the context where it will take place.

Its applicability allows us to use it as a valuable program planning tool, a project management tool, and/or a tool for stakeholder collaboration.

3.4.8 Importance of adopting the USP Model

One of the most significant barriers identified by the authors in the field of academic research is the fact that when implementing research projects, academic researchers do not have the time. It is necessary to plan a program, develop projects, and structure initiatives within it. The time required to acquire the necessary skills to solve complex problems (Risopoulos-Pichler et al., 2020) is incompatible with the reality of teaching and research. The authors chose to investigate the processes necessary to acquire a shared vision that clarifies the direction of goals, metrics, and controls. Furthermore, this shared vision fosters transparent communication with associations, collaborators, and interest groups, facilitating mutually reinforcing activities. These activities, in turn, will promote the sustainability and scalability of the programs generated with the help of the USP Model.

3.4.9 The USP for JSHS

Applying the USP model to the work of the JSHS allowed a rapid understanding of their current situation and the development of a strategic plan to implement virtualization. Moreover, having utilized the USP model in this way allowed an easier transition to full virtualization during COVID-19.

3.5 Results

As time passed, the USP allowed the committee to co-design the program's new vision, including virtual poster and paper submission, reviews, judging, and final presentations. Thanks to the work with the USP, these efforts prepared the program to

respond to the challenges of COVID-19 and even thrive growing the program by nearly 150% of accepted submissions.

During the 2021-22 round of JSHS, a new lower-division virtual "3-Minute Research Pitch" pilot program for younger participants aged 12 to 16 was collaboratively developed following the USP model. This initiative aimed to increase the interest of younger participants and provide a larger pool of applicants and higher quality submissions. This growth strategy is only possible due to clear planning. Another aspect that has been identified due to the USP is the need for a coherent set of metrics related to recruiting and outreach as well as reach and engagement tied to social media and other communications strategies.

3.6 Implications

The authors consider that the impact of the USP Model in research with collaborative infrastructure will be very useful for the development of academic research, given that the study of strategic planning adds direct value to the administration and management of projects both for the simplicity of its structure, as well as the direct integration of the explored definitions. Its flexibility as a planning or project management tool allows its implementation to generate added value for the researcher and the community in general. Similarly, one of its main strengths is the ease of visualizing the logical flow of the project as a whole, which will result in the optimization of human resources, the interaction of diversities, generating and enrichment of ideas, and fostering of collaboration. Finally, concerning the applicability, we have worked with this model, in an exploratory way, with groups of researchers in Science, Technology, Engineering, and Mathematics, (STEM) as well as the area of social sciences and education at the New Jersey Institute of Technology in New Jersey USA.

The USP Model has been received with great satisfaction, generating collaborative enthusiasm in the academic community,

and the enrichment caused by the diversity of contributions, it should be noted that, at the New Jersey Institute of Technology, it has been applied in research projects that have achieved state and federal funding from the US government.

Chapter 4. STEM literacy and Trans-Disciplinary Communication

National Science Foundation's (NSF) Science and Engineering (S&E) indicators clearly state the significant need for more and improved training in STEM and related fields. NSF and many other organizations have documented the growing gaps in the needed capacities among US citizens and our failure to produce enough appropriately skilled members for our workforce. Central to all of this are the many literacies that continue to be lacking: lack of scientific, information and technological literacy all lead to a lack of understanding of what research is, how knowledge is deemed 'true', and what the pillars of a reasonable argument are. Evidence of the pervasive lack of scientific understanding is seen in the many persistent popular beliefs: flat earth, the connection between vaccines and autism, denial of global warming, the substitution of anecdotal experience or personal belief for true scientific study, etc.

In this chapter, we explore some of the basic principles of STEM Literacy and the affiliated concepts of communication. Without effective communication, the view of STEM is incomplete and may not be fully effective. STEM is in everything we do and so the ability to effectively communicate across disciplines and to every level and background of the listener is essential. At the same time, simply being an effective communicator is necessary but not sufficient. Persuasion is a double-edged sword since without it many may not understand or believe what experts say, however, at the same time, those who seek to cloak themselves in the language or feel of science can persuade others to faulty ends or even blatantly false conclusions and beliefs.

4.1 Integrated STEM Literacy

Before specifically researching collaboration, Dr. Lipuma focused on STEM Literacy. The key research question he works to answer is "How do we prepare everyone to be STEM literate to meet the challenges of global competitiveness, technological innovation, environmental change, and social and political strife?" An integrated approach is needed to ensure that citizens acquire the literacy skills essential to continue our leadership in innovation in STEM and to prepare our workforce for success in the 21st century.

STEM education is essential to sustain the pace of innovation and progress so that our citizenry can understand and knowledgeably engage in debate about an increasingly complex world in which anyone can access and disseminate "information" via the internet. Yet, many studies indicate the need for more K-20 collaboration and communication among diverse groups to ensure a clear understanding of the basic principles of STEM. Many students have persistent misconceptions about science and even many highly educated STEM professionals still carry such misconceptions with them. The lack of understanding of research methods, inability to differentiate fact from fiction, and lack of habits of mind concerning STEM, in addition to the increasing separation of the average citizen from understanding how STEM disciplines impact their lives, poses many significant challenges and research opportunities. No one has studied the entire system to seek an integrated approach to information literacy and literacy in STEM and an appreciation of design thinking. Extensive collaboration at all levels and research into the ways to address these persistent problems is needed at all levels and across all boundaries. Key aspects of STEM literacy include:

- Agreement about the accepted body of knowledge in STEM disciplines and the processes for arriving at that consensus
- Understanding the habits of mind and methods of STEM practitioners

- Ability to use the fruits of STEM innovation, research, and development
- The capacity of everyone to engage in rational debate and come to informed decisions about current issues in a civil manner, especially involving STEM Essential to these efforts are information literacy, an understanding of research and critical analysis of information sources, and the way people seek answers to questions and judge the results found.

There is much research highlighting the extent of the problem at all levels of education and in society at large. Current generations have grown to accept answers provided by the internet, our devices, or someone who sounds like an "expert". This leads to a series of research questions: What are effective ways to promote STEM literacy at all levels? How do we promote effective collaboration and communication of ideas across disciplines and from STEM professionals to the general public? Are the broader impacts of NSF-supported research reaching and impacting the public? What role do changing conceptions of integrated approaches to STEM and including arts and design play in the development of creativity and innovation?

- To what level can interventions at early ages combat the persistence of misconceptions and aid in the recognition of pseudo-science and non-science?
- How might teachers and STEM professionals be trained to act as role models and mentors both to promote higher levels of STEM literacy and encourage greater participation in STEM?
- Why does it matter? What scientific discoveries, innovations, and desired societal outcomes might result from investment in this area?

4.1.1 Why does STEM literacy matters?

Information, scientific, and technology literacy, or more broadly STEM literacy matters because STEM underpins our society and without an informed citizenry our leadership in innovation and creativity and our ability to compete globally will be threatened. Through effective collaboration and communication, we will be able to meet the challenge and continue to develop, innovate, and create a brighter future. Understanding how best to prepare *all* students from an early age and support their development from cradle to career means we take advantage of our diversity and interconnect all sectors of our population to develop a stronger, more resilient, and tolerant society. Through increased sharing of knowledge and by taking a collective impact approach, we will efficiently reduce duplication of effort and eliminate the revisiting of settled debates. STEM is always open to the reexamination of ideas when new data arises or more accurate models and explanations are provided that fit the situation more accurately. However, nowadays it seems as though there are many attacks on STEM based on false logic, rehashing of already discredited work, and a sense that everyone is entitled to their facts. If we can understand all aspects leading to this problem, we can improve methods to educate all students in a more rational and STEM-centered manner. This will reduce obstacles and unproductive debates, enabling our society to move forward more effectively and quickly. Everyone must have free and easy access to the world of STEM and the benefits that literacy in STEM provides. By funding this work, the lives of all children and, later, all Americans will be improved through a concerted effort to understand how best to prepare the workforce for the coming decades. The pace of innovation is such that today's technologies will long since be obsolete and the jobs we see now for college graduates will not be the ones for which the next generation will be needed. The generation after that may not even know that the current jobs existed. Moreover, each person must have the knowledge, skills, and capabilities to act wisely when confronted with choices and the ability to communicate their ideas and thoughts. The capacity to understand STEM and the research process and to judge the

validity of the torrent of information constantly being produced will be essential to function successfully in a society built upon the fruits of STEM research and development. Thus, we must learn how to teach, promote, and support STEM and information literacy for all. Without this research, the mission of NSF will be appreciated and supported by an ever-shrinking minority, while the rest will be left behind. This could lead to the inability of the US to compete effectively and reduce our ability to lead the world to a better future.

4.1.2 What would success look like and why now?

Success takes several forms with different metrics. Most simply, new materials for K-20 education will be generated and used to develop an expanding STEM-literate workforce and information-literate citizenry. The number of productive STEM professionals will increase and be better prepared, not only for their role in the economy but also as informed citizens well equipped to participate in civic activities. Beyond this, greater engagement in collaboration and communication will increase the pace of innovation and spur new and expanding developments in all areas of STEM. This integrated perspective and collective impact approach will leverage work being done throughout the STEM community, and lead to breaking down silos and building bridges to foster more effective practice. STEM professionals, especially researchers, will have the tools to engage more fully in collaborating, sharing work, and promoting the next generation of STEM practitioners. If effective, successful collaboration at and among all levels will increase engagement. Most significantly as a marker of success, Integrated STEM Literacy for All in the 21st Century will bring together disparate groups of US citizens to become more productively involved in all aspects of STEM endeavors, careers, and citizenship. Informed by STEM knowledge and equipped with the tools to work together more effectively, there will be greater integration among K-12 educators, the higher education community, the general community, industry, and government. This will enable us to see and address pressing national needs more readily, as all communities gain voice and representation. The effort will boost collabora-

tion and effective communication, leading to a more fully engaged citizenry and continued US leadership in innovation.

As the pace of knowledge creation and technological advancement will only increase, continued US leadership in STEM and innovation demands information and a scientifically literate populace. With greater interest in socially conscious practices and an increasingly diverse population, ALL communities must be engaged in moving our country forward. There is a need to build the required educational infrastructure to adapt to these developments. Currently, there is a key shift from simple curricular disciplinary instruction to one focused on creativity and

STEM/STEAM design. This allows for the creation of new paradigms and the reform of curricular approaches and materials. The ubiquity of inexpensive digital tools increases the ability to spread widely and quickly those lessons learned in this research to produce a nation that is STEM literate and confident in the use of information, science, and technology that leads the world forward toward a brighter future.

4.2 Trans-Disciplinary Communication and STEM Literacy

As our work moved into areas that are more inter-disciplinary and engaged others in co-design, effective communication became more necessary when collaboration occurs within a focused area of study, a single subject, or even with a defined discipline, communication may be taken for granted or focused on accurate translation from one language to another. However, as collaboration moves towards inter-disciplinary interactions, perspectives, cultures, and private language or jargon become an issue.

In STEM this same issue of interfacing content areas, backgrounds, cultures, etc. holds true. however, STEM must also transcend simple academic conversations and engage a wide

range of stakeholders both to inform and at times persuade them of what STEM does and/or holds as true.

In any large social change initiative, being able to leverage effective trans-disciplinary communication will be a key factor in success. Moreover, a large portion of those involved may have differing backgrounds and approaches not to mention interests and attitudes. Due to this, a rational logical approach may not fully solve the communication and collaboration challenges faced as STEM professionals and educators interface with the public across the globe. The wide range of potential interactions and communities with their cultural perspective necessitates the need for persuasion to engage in STEM Literate discussions. At the same time, however, logical arguments and weight of evidence are the language of STEM literacy but may not be how everyone sees persuasion.

4.3 Persuasion in Research

Throughout our research and reviews of the literature on Trans-Disciplinary Communication (TDC) and STEM, we have identified different goals for expert communication around STEM. Researchers can discuss concepts amongst themselves as part of the activities of STEM professionals to move the study and products of STEM forward. Going beyond this level, they disseminate and divulge their work and findings. While disseminating the primary function consists in increasing the visibility of research activities, outcomes, outputs, and impact. The intention of this type of communication is to generate peer engagement in science, methods, process, and innovations. The discussions and dissemination invite others to review and understand the work as it is being done within the discipline.

When divulging the primary function concerns making science comprehensible to the public while stimulating intellectual curiosity. The intention of this type of communication is to draw the attention of society to their research conclusions, enhancing comprehension, implementation, and translation. This type of

communication is essential for education and the continual development of new professionals as they are inducted into and develop as part of the discipline.

However, in modern society, STEM findings are not always assumed to be known or accepted. Thus, part of TDC with the general public involves the need to persuade and educate as the larger community is engaged. In this scenario, effective communication is vital to engage in TDC and enact persuasion to attain the desired goal. Some scientists focus on persuading fellow STEM professionals and researchers, but that is typically handled through established procedures and rules of evidence within of new disciplines in question.

When engaging in TDC around STEM, there may be more effective approaches than relying solely on logic. Other types of persuasion that involve emotions, perceived value, and reputation can also play a role, thus adding a barrier to the communication process. It is, therefore, essential to discuss the term "persuasion" in the context of research and consider the Aristotelian "Trinity of Persuasion" which includes ethos, pathos, and logos. This remains as relevant today as it ever was.

Creating the foundations of "Persuasion" as an explicative principle and its differences from the common practice in communication, marketing and politics will benefit society at large thus fulfilling the Trans-Disciplinary need for understanding and clarification in terms and taxonomies for researchers around the globe.

Our research has led us to a series of essential questions in this area that we will work to answer:

- What should be the objective of an academic presentation in the context of research?
- Should researchers advocate for their position or seek to contribute to the disciplinary body of knowledge and the larger society as a whole?
- Is the quality of rhetoric and the measure of reputation a means of enabling effective communication or do these

factors persuade others in a way that detracts from overall STEM literacy?

Chapter 5. Integrating models for effective Collaborative convergence

In this chapter, we present the application of the concepts and models examined previously. As the work of individuals within a community, discipline, or area of interest recognizes larger vexing issues, collaboration and extra-disciplinary interactions become necessary. In our work with STEM education, the tools of digital learning and communication made it possible to reach a wider audience but necessitated formalization and expansion of our efforts. Working with others to use the Co-Design Approach (CDA) for solutions and learning at the interfaces of multiple sectors across diverse communities led us to the examples provided herein. We hope that these simple descriptions and resources can assist others to better understand our research and practice as well as facilitate their own agency and actions.

5.1 Virtualization as a strategy for collaboration and communication

Technology has transformed the way we communicate and collaborate. However, many traditional methods are still employed and can be effective. Our research is not working to persuade everyone to do everything virtually. However, when the option is available as a method of instruction, communication, or collaboration, it must be understood and used effectively. As with any technology, leveraging it to attain a goal must involve understanding how it works and how that functionality might enhance outcomes.

The concept of virtualization has advanced greatly during COVID-19. Meetings are held with teleconferencing, collaboration is managed with virtual documents, digital learning management systems facilitate all aspects of learning, and cameras and devices are now an essential part of our everyday learning life. A significant part of the foundation of our work and research relates to a clear understanding of our work. Clearly expressing what we envision and how it comes together and is planned and implemented did not just emerge. The design and development of our personal and programmatic strategic plan, project management, and overall communication and evaluation plans took time Virtualizing these materials was a large factor in being able to collaborate and engage in effective co-design. Rather than just having our ideas, values, and principles in our heads, it was available on the web. Instead of just writing ad copy documents, we developed digital materials and videos to enable our partners and other stakeholders to see what we are working on, our plans for advancing the work, and the tools and resources we wish to share with everyone. Moreover, virtualizing our communication and collaboration allows us to offer our resources and work with others to come to a mutually shared vision of how our work and that of others can find synergy to reach a wider audience and attain our shared goals more effectively.

5.2 CLEAR Case

In order to help illustrate how we used the tools of the USP to facilitate communication and collaboration, we will first examine the NJIT College of Science and Liberal Arts (CSLA) Collaborative for Leadership, Education & Assessment Research (CLEAR). The academic center intended to enhance internal collaboration amongst members of the various departments at NJIT as well as encourage outreach with our community.

5.2.1 CLEAR strategic planning

Vision:

The Collaborative for Leadership, Education, and Assessment Research (CLEAR) at NJIT promote pathways for the success of students in college, career, and citizenship in the digital age through a multi-stakeholder approach.

Mission Statement:

CLEAR's mission is to support effective education and collaborative leadership through the use of educational best practices and technology.

Goal:

CLEAR's goal is to develop programs and activities for stakeholders that promote networking and collaboration.

Objectives:

Vital to the success of CLEAR's charge are the following initiatives:

- Promote collaboration to integrate and advance disciplinary activities, knowledge, and practices through STEM and STEAM initiatives
- Increase and broaden participation in STEM and STEAM opportunities, majors, and careers, especially for women and underrepresented minorities
- Promote the effective and efficient utilization of digital learning tools in curriculum, instruction, assessment, and professional development

Brand Mantra:

Supporting effective education.

In the end, the work of CLEAR led to the attainment of numerous grants and funded projects. The planning and project management assisted members to engage with one another and our larger community. However, to fully address large-scale social issues and engage more partners, something larger and focused outside of NJIT was needed. Building upon the NSF INCLUDES Design and Development Launch Pilot (DDLP) the same tools were used to create the STEM for Success Project and its strategic plan and collaborative infrastructure. CLEAR and STEM for Success have been integrated into the strategic plan for CSLA, thus impacting the policy and planning of the college as we enact the shared vision for ourselves and our partners.

5.3 STEM for Success case

STEM for Success is an integrated program to broaden participation in STEM, especially for those in traditionally underrepresented groups (TUGs). Our three initiatives are fostering collaborative community engagement, providing STEM education resources, and the Active Learning Academy.

5.3.1 STEM for Success strategic planning

Just Cause:

STEM for Success just cause is to empower children to have freedom and agency to follow their path and solve the problems they will face as they pursue their passions in life. We are looking for people to collaborate with us as we enact our vision.

Vision:

STEM for Success envisions a system to broaden the participation of children in STEM, especially among traditionally underrepresented groups.

Mission:

STEM for Success fosters collaborative change in STEM by engaging multiple stakeholders around STEM experiences.

Goal:

To establish a digital repository to collect, share and showcase STEM accomplishments of students as they develop skills to become productive members of the future workforce. In this way, we will achieve persistent participation.

To better prepare the students in acquiring these sets of skills. We will help to foster a growth mindset, critical thinking, reflection, problem-solving, leadership, communication, collaboration, and other essential skills.

To meet all children where they are and provide multiple sustained ongoing STEM experiences so that students will be able to pursue multiple paths to explore and follow their passions.

Values:

- LEADERSHIP: Leadership is taking responsibility for yourself and others to achieve goals.
- TEAMWORK: Teamwork is individuals cooperating towards the successful attainment of a common goal, through a shared vision, distributed leadership, commitment, agency, and action.
- EDUCATION: Education is a system of planned experiences and activities to facilitate learning and foster Science Technology Engineering and Math (STEM) literacy.

- INNOVATION: Innovation is the inspiration, imagination, and integration of new ideas or new ways to apply an existing idea through research and development.
- PASSION: Passion is investing your human capital to serve others to achieve a common purpose.
- AGENCY: Agency is taking action to attain your end and make positive change through self-efficacy and self-directed learning leveraging partnerships and collective action.

Principles:

- SOCIAL RESPONSIBILITIES: Individuals and organizations have an ongoing and committed ethical obligation to act to benefit society at large.
- COLLABORATION: Effective individuals work with others in teams with a shared vision to attain a common goal together (Peer engagement).
- COLLECTIVE IMPACT: Leadership and organizational support through a strong backbone are essential for programs to harness individual inputs to reach scale and be successful (Organization engagement).
- COLLABORATIVE CHANGE: To truly create large-scale sustainable change, individuals and organizations must come together mindfully to change the situation and the system (System engagement).

Philosophy:

How we collaborate: Co-Design with Community.

Brand Mantra:

Promoting Success Through STEM.

Tag line:

STEM is in everything we do.

Chapter 6. Planning, visualizing, and intention alignment

In this chapter, we go beyond individual, team, or organizational collaboration and communication. Using the example of our NSF INCLUDES Alliance proposal, we present the foundational ideas that bring together several organizations around a common goal and shared vision. Together, we work to make a positive impact on the system that could not be achieved individually. At the same time, this process necessitates TDC and collaborative convergence to help everyone understand what aspects of the issue we can tackle and how we can work on this together to make progress. This Alliance is just beginning but building on what has come from our previous work, we hope to build a sustainable means of promoting STEM literacy and broader participation for all.

6.1 S4S Alliance Shared Vision

Their LiFE project experience led the PIs to formulate the key research questions that drive the current S4S Alliance proposal:

1. How can we improve data collection and shared metrics?
2. How can females share their knowledge to broaden participation in STEM?
3. Why do women and other under-represented groups choose or not choose to participate in STEM opportunities (clubs, activities, challenges, competitions, etc.)?
4. What influences decisions to participate or to continue participation includes factors such as the participants' peers, educators, parents, mass media, and social media, as well as their own emotional experiences, interactions

with leaders, feelings of belonging, the opportunity for teamwork, and feelings of purpose and contribution to society.

5. What paths are most common for opted-in participants, opted-out (non-)participants, multi-year participation in the same or similar experiences; multi-year participation in a variety of experiences? For those forced to stop by the system or lack of opportunity? For those who choose options other than STEM?

6.1.1 S4S Collaborative Infrastructure

STEM 4 Success (S4S) envisions increased participation for females in STEM experiences with support to enhance awareness, access, and sharing. This will lead to broader participation as each person joins a STEM pathway and support network leading toward a future STEM career. S4S fosters collaborative change and broader participation among females in STEM by engaging multiple stakeholders around STEM experiences. The Alliance will create a set of common metrics aligned with the NSF INCLUDES Network shared metrics for program participation. In addition, new metrics tied to communication and collaboration will be created, tested, and disseminated widely. Through the STEM for Success advisory board and CLEAR's backbone, the Alliance partners will come together to co-design the new space for this much-needed social innovation.

6.1.2 Broader Participation Challenge

The challenge we identified is the disengagement of females in STEM related to divergent, isolated, and siloed STEM experiences, often promoted as enrichment, extra-curricular, or disjointed projects that are not connected one to another. This lack of synergy and context must be addressed to constructively align the STEM experience of each participant. Participants must be engaged in collaborative efforts that provide meaning and the ability to communicate safely and confidently about their work, desires, and situation, leading to agency and creativity. For females especially, community context, collaboration,

and the ability to display work over time creatively promote personal identity and meaning through STEM experiences. This increases both the attractiveness of STEM to the student and increases student interest and persistence.

6.1.3 Goals and Metrics

S4S aims to understand the decisions made by females concerning their participation in STEM experiences. This will inform the ecosystems that surround and support them. Our particular goals and initiatives are:

- G1-To learn why females persist or not in STEM. In this way, we will acquire a better understanding of the decisions of females in order to enhance the effectiveness of all support programs.
- G2-To administer a digital repository to collect, share and display STEM accomplishments of students as they develop skills to become productive members of the future workforce. In this way, we will achieve persistent participation.
- G3-To develop opportunities to promote STEM awareness at a national level. In this way, we will be able to promote exemplars who encourage females and people from under-represented groups in STEM across the nation. This will also allow our local and regional activities to connect with their national and international footprints.

As a backbone, NJIT will continue to manage the interactions of the S4S advisory board as well as recruit members aligned with our vision. The shared vision and mutually reinforcing activities of the Alliance will be enhanced by the leadership and constant communication managed by the backbone.

The alliance will be enhanced by the leadership and constant communication managed by the backbone. A significant step towards this synergistic alignment is the development of a social media playbook and a common communication protocol.

These guides will allow all members of the Alliance to speak a common language, leverage the engagement and reach of one another, and reinforce the efforts of everyone through best practices for modern communication strategies. Additionally, the backbone staff will facilitate the communication of activities with the NSF INCLUDES Network and the larger community of practice and networks interested in the work and opportunities. In particular, this will allow more stakeholders to be aware of, access, and share the materials and supports S4S provides.

Collaborating with Partnerships in Education and Resilience (PEAR) allows S4S's backbone to co-design vital aspects of the effective program and help increase inter-partner communication and collaboration. This collaboration will yield a clear set of tangible goals and metrics for each partner tied to the evaluation protocols and data dashboards provided by PEAR and widely disseminated by New Jersey STEM Pathways Network (NJSPN).

NJIT will organize and host partner and professional development events for our partners and participants. The collection and sharing of data on Traditionally Under-represented Groups (TUG) participation in STEM is essential in creating S4S's shared vision and promoting NSF INCLUDES common measures aligned with S4S's shared goals and metrics. This will lead to a better understanding of the long-term trends so data-driven decision-making best practices can be adapted and measured over time for effectiveness. This will also allow these practices to be disseminated throughout the Alliance partners and their networks to create a longitudinal picture for everyone to customize, thus optimizing the impact and sustainability of programs to increase equity and participation.

6.1.4 Mutually Reinforcing Activities

A major rationale for bringing the many partners together into this Alliance is to ensure representation of the four sectors in the collaborative convergence research approach: Academia, Government, Public and Private Organizations, and society that

surrounds and comprises many of the stakeholders in the work. As a backbone, Collaborative for Leadership, Education, and Assessment Research (CLEAR) must also ensure that the development of tools and the work of scaling and sustainability is served. Thus, there are partners representing various stages of work and scope of reach. The partners in the Leadership and iSTEAM for Females in Elementary School (LiFE) project are interested in continuing their collaborations, as are many of the other collaborators of STEM for Success. Despite COVID restrictions, LiFE partner Morris Plains joined the Alliance to assist with the co-design of the work. Similarly, the many ecosystem members represented by NJSPN see the benefit of involvement with the Alliance. NJSPN has worked with CLEAR to develop showcases for STEM Month during our LiFE project that provide examples of how this can be expanded. Junior Science & Humanities Symposium (JSHS) at Rutgers seeks to generate more local interest and so helped CLEAR co-design the High School Female STEM Research Invitational as a way to provide a continuation and expansion of the program and share those insights with the larger JSHS national organizations. As we engage with schools and educators as well as public and private organizations, S4S remains true to its stated vision and mission supported by its strategic plan and communication and outreach activities.

6.1.5 Partners alignment map

S4S used a partners alignment matrix to match our strategic plan to the collaborative infrastructure and work of our partners aligning our Goals, Initiatives, Metrics, and Partner Activities (GIMPA) as shown below in Table 4.

Table 4. Strategic Alignment Matrix: GIMPA[1]

Goal 1: Learn why females persist or not in STEM. In this way, S4S better understands the decisions of females in order to enhance the effectiveness of all support programs.

[1] Reference: CI indicates Collaborative Infrastructure; SV=Shared Vision; P=Partnerships; GM=Goals and Metrics; LC=Leadership and Communica-

Initiative Short term	1S-Develop valid and reliable instruments to be shared at local and regional levels **Actions** • Developing and administering the survey • Analyzing the survey data • Sharing survey results among partners
Initiative Long term	1L-Distribute survey results at a national level **Actions** • Encouraging the adoption of survey instruments openly and widely • Sharing survey results nationally.
Metrics	Progress toward a valid and reliable tool # of focus groups run # of people completing the surveys
Partners	PEAR Institute, School districts, NJSPN, InterNational STEM League (iNSL), New Jersey School Boards Association (NJSBA), and Ten80 Education (Ten80)
CI Element Backbone role	LC-NJIT will coordinate the work of PEAR with partners to gather baseline, develop tools, and facilitate progress and communication. GMs are managed to ensure the survey development and testing proceeds, LC: All parties are involved in the co-design of the instruments, and training, ESS: The survey tools will be shared across S4S to ensure validity and reliability as well as increase the baseline for all partners.

tion; ESS=Expansion, Sustainability, and Scale.

Goal 2: Administer a digital repository to collect, share and display STEM accomplishments of students as they develop skills to become productive members of the future workforce. In this way, S4S achieves persistent participation.	
Initiative Short term	2S-Engage the larger STEM communities by providing STEM educational resources. **Actions** • Publishing STEM journals • Organizing and hosting conferences • Expanding digital repositories: showcase materials and educator tools
Long term Initiative	2L-Scale the repository at a national level **Actions** • Synergizing with partners who can expand interest through their network • Scaling and recruiting groups to join and contribute to the Alliance's digital repository
Metrics	# STEM Journals published # of artifacts added to the repository # of items related to issues of females in STEM Conferences: # of conferences # of events Resource usage: # of downloads; # of distribution by state; PlumX metrics (proprietary 51 data points for Digital repository from Digital Commons provided by NJIT) # google analytics for traffic and other metrics # of new organizations added contributing to the repository % of items added to the repository in-state / out-of-state / internationally # of states/countries contributing

Partners	Red de Investigadores de Juegos de Rol (RIJR), INSL, JSHS, NJSPN, NJSPBA, School districts
CI Element Backbone role	SV: CLEAR oversees NJIT Digital Commons to match new content with the S4S vision; GM: meet the metrics of content and publications with S4S staff and researchers; LC: maintain scheduled production of journals, conference pages, event notices, and coordination of S4S partner activities; ESS: Promote S4S offerings, recruit new partners, and publish widely.

Goal 3. Develop opportunities to promote STEM awareness at a national level. In this way, we will be able to promote *exemplars* who encourage females and people from under-represented groups in STEM across the nation. This will also allow our local and regional activities to connect with their national and international footprints.

Initiative Short term	3S-Share activities to engage potential partners to expand, sustain and scale the Alliance at a regional level **Actions** • Increasing participation by females in partner STEM activities • Connecting our ecosystem with the NSF INCLUDES Network • Recruiting new partners

Initiative Long term	3L-Share products developed through co-design to engage potential partners at a national level and scale the Alliance **Actions** • Increasing offerings, growing breadth of organizations running events • Engaging members of the NSF INCLUDES Network proactively • Expanding advisory board, Recruiting partners with national reach
Metrics	Regional level # of regional organizations added # of new organizations added to the Alliance # of participants (females) reached # of partners connected with the NSF INCLUDES Network and Hub # of conferences/events and locations # of participants (females) in national events # of partners/reach added at a national level # growth of advisory board # posts on INCLUDES Network # feedback/interactions with the NSF INCLUDES Network members
Partners	STEM Ecosystems, National JSHS Community, RIJR International Community

CI Element Backbone role	SV: New partners will be on-boarded and our shared tools and metrics will be provided to engage them in the Co-design process. LC: CLEAR will lead the effort to add new partners, recruit financial support and assist existing partners to expand and scale work based on their scenarios. New partners are trained on S4S tools. GM: baselines are established and new partners are oriented to the Goals and metrics as their materials join the S4S resources and are aligned with activities. SES: As detailed in this section and below, the backbone will support the expansion of partner activities while refining Good Enough to Share (GETS from the US Army) and distributing it widely.

6.2 Logic Model Guides and Examples

A logic model is a graphic organizer for your plan, it answers what and how will results be produced. Logic models are also known as Monitoring and Evaluation (M&E) frameworks and are sometimes referred to as logical frameworks. In general, the logic model is similar to a logical framework, but it is presented differently. They are commonly used by projects funded by United States Agency for International Development (USAID) or the United Nations (UN).

The purpose of logic models is to present a clear plan for the use of resources to meet the desired goals and objectives. They are a useful tool for presenting programmatic and evaluation components.

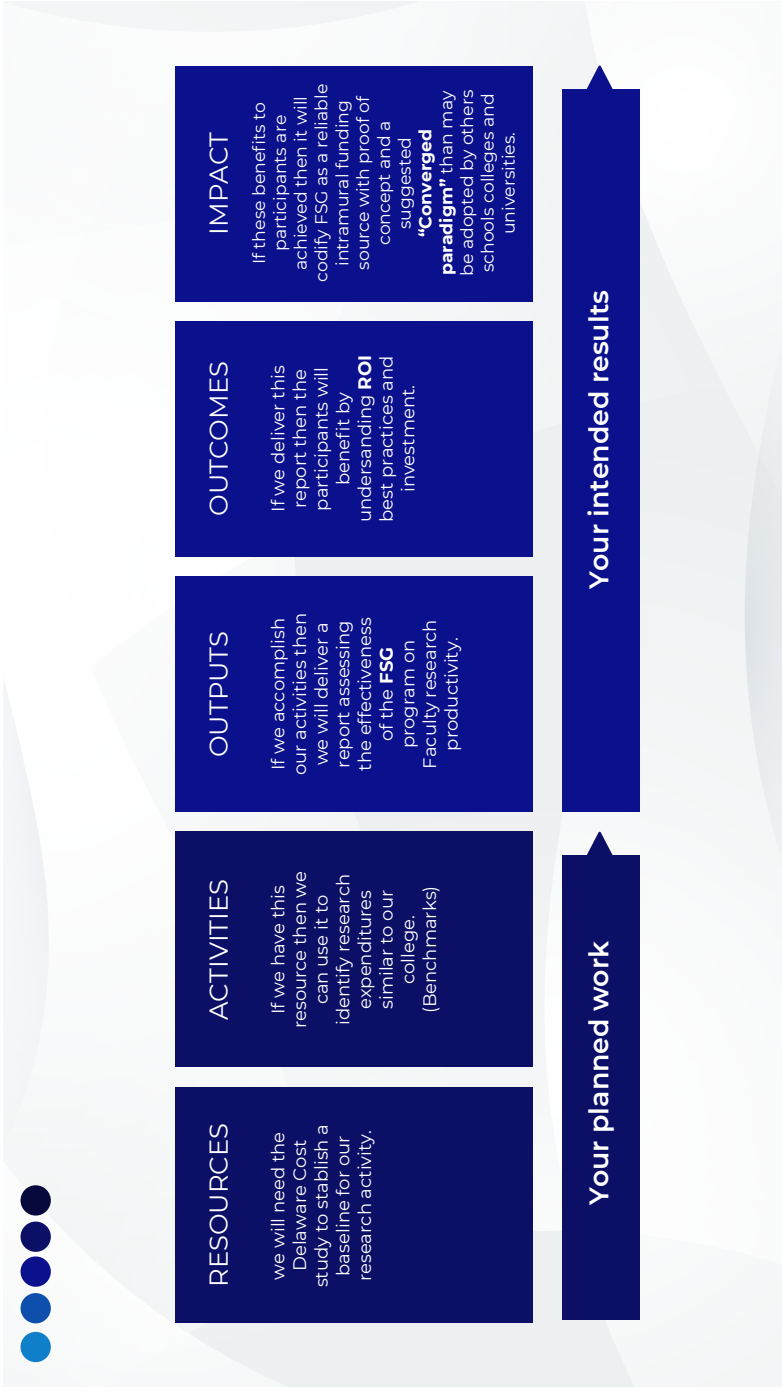
An underlying assumption of logic models is that there is a linear relationship flowing from program inputs to processes/

activities, which, in turn, result in outputs that ultimately lead to long-term outcomes and impact. Inputs, processes and outputs pertain to what the program does while outcomes and impact pertain to what the program sets out to accomplish.

- Inputs: The resources invested in a program, for example, technical assistance, financial resources, infrastructure, and equipment.
- Processes: The activities carried out to achieve the program's objectives, such as training and outreach.
- Outputs: The immediate deliverables of a program achieved through the implementation of activities, such as providers trained or bed nets distributed.
- Outcomes: Short-term and intermediate results at the population level achieved by the program through the implementation of program activities, such as changes in people's knowledge, attitudes, or behavior.
- Impact: The long-term effects of a program, for example, changes in health status.

The following figure (see Figure 6) outlines the primary components of a logic model.

Figure 6. Primary Components of a Planning Model



Ideally, health program planners and managers will develop a framework or model during the program planning stage, after they have articulated the health problem and contributing factors and identified potential solutions. The framework is comprised of the activities, outputs, outcomes, and impacts that the program managers intend to change over the life of the program. A framework also helps program managers identify appropriate indicators that the M&E team will track to ensure that the program activities are leading to the end goals. If a program manager begins to implement activities before a particular framework has been established, it is still useful to construct a framework to map out these important considerations.

6.3 The Six Basic Elements of a Logic Model

Problem. A statement referring to a current condition perceived as harmful to a client system. A comprehensive description of the environment, resources, characteristics, behaviors, attitudes, or attributes which are problematic.

Goal. A statement describing a future condition perceived as desirable and feasible that will solve or ameliorate the stated problem.

Objectives. A series of statements that describe steps that must be accomplished if the goal is to be achieved. They are components of the goal and are more limited in scope, less abstract, more concrete, and thus measurable.

Inputs/Resources. A series of statements that list all the things, tangible and intangible, needed to accomplish the objectives.

Methods. A series of statements that list all the processes applied to the resources to produce the desired result(s) and outcomes.

Results and Outcomes. The short-term and the long-term effects of applying the specified processes to the inputs/re-

sources identified. Results can (and should) be measured as the client/client system exits the program; outcomes can only be measured by following the client for a specified period.

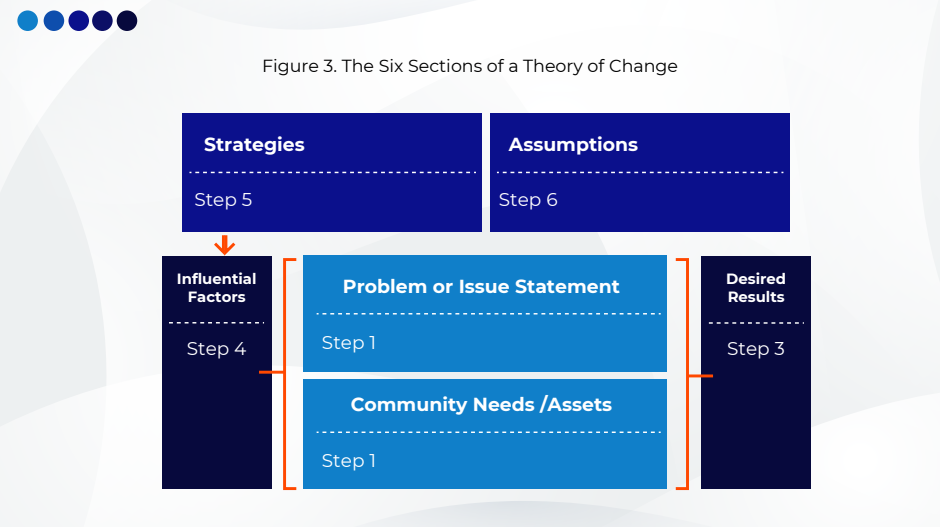
6.4 Theory of Change and Logic Models

A Theory of Change (ToC) is a graphic organizer for your rationale, it answers the question *why will this work?* Here we need to organize six sections.

- What is the problem (or vexing issue)?
- What are the community needs?
- What are the desired results?
- What are the influential factors?
- What strategies will be implemented?
- What assumptions do you have?

The following figure (see Figure 7) describes the six main components of a Theory of Change.

Figure 7. Six Sections of a Theory of Change



Chapter 7. Reflections on Collaboration

This book was a means for organizing and sharing our work from recent years that built upon diverse experiences with numerous wonderful people. All of us seek our own ends and face challenges. Sharing the work makes the lift easier and the journey more enjoyable. This is where we stand today but tomorrow everything will change. Our challenge is that the system is comprised of humans and so that change can be positive for all. Our particular experience and aim relate to STEM education as a focus for the examinations of social change and broadening participation to benefit all. This final chapter is our reflections on what has come thus far to get us to this point and a look forward as we move to large-scale work with a wider array of partners, from a much larger community of interested stakeholders from around the world.

We hope to strike the balance between breadth and depth so we can attain our goals and benefit the most without being overwhelmed by the tasks or becoming lost in the many side channels and discussions that will certainly arise. None of us has all the skills needed in the modern world but hopefully, together we can collaborate and communicate toward change that is effective for all.

7.1 Reflection from Lipuma

I am amazed by my small role in the conversations that occur at the many levels of collaboration and interaction. My everyday work involves educating undergraduates to foster a sense of the interaction needed for effective collaborative leadership and communication. My research has grown well beyond that as I worked with my colleagues and partners to act on a perva-

sive vexing problem facing all of us—how to empower all young people to be self-directed in their learning and ready for the challenges of tomorrow. Perhaps selfishly, I seek to encourage as many as possible to experience thought in action and use the tools of STEM. I believe STEM is in everything we do and through basic training in the tools of STEM and its wondrous products, everyone can find benefits. Moreover, in order to face the unknown challenges of the future, I am confident that the generations that follow us can prepare themselves to meet all challenges and exceed every expectation.

It is through this lens that I look to build alliances and enact social change through collaboration resting upon a firm infrastructure. I know this goal is not easily attained, simple to achieve, or pursued alone. Only through a sustained effort to establish and sustain our efforts and continually expand and embrace our work can something like this be attempted. In the end, I may only be a spark but if I have worked to gather the right tinder and prepared the forge correctly, the fire that I might light can be used to create something that will last and light the way for those that come after me.

7.2 Reflection from León

I am truly honored to have this creative collaboration with the co-authors of this work. My everyday work involves sponsored research administration fostering the necessary communication and support that faculty members need to pursue their agendas. My research has benefited from the conversations presented in this book but mainly from the shared vision and intercultural collaboration that is necessary when approaching the pervasive vexing problems of society. I share with Dr. Lipuma and Dr. Guzmán a strong belief that education and the tools of STEM will prepare the present generations for future challenges. I hope that more people learn and experience the benefits that collaboration and convergence bring to disciplinary research.

7.3 Reflection from Guzmán

I am honored to have participated in the edition of this book with Dr. León and Dr. Lipuma. This research project, without any doubt, will be very helpful to determine all the skills needed for competitive professionals who have new challenges in this new century.

This publication describes Strategic Models for education and research. It accurately combines the characteristics of strategic planning and academic research management. Besides, it considers the logic models, the theory of change and project management. As a result, this innovative book will help all the actors in the education sector to sustain theoretically future research.

As an educator, I consider the topics discussed here invaluable to forming future investigators interested in collaboration.

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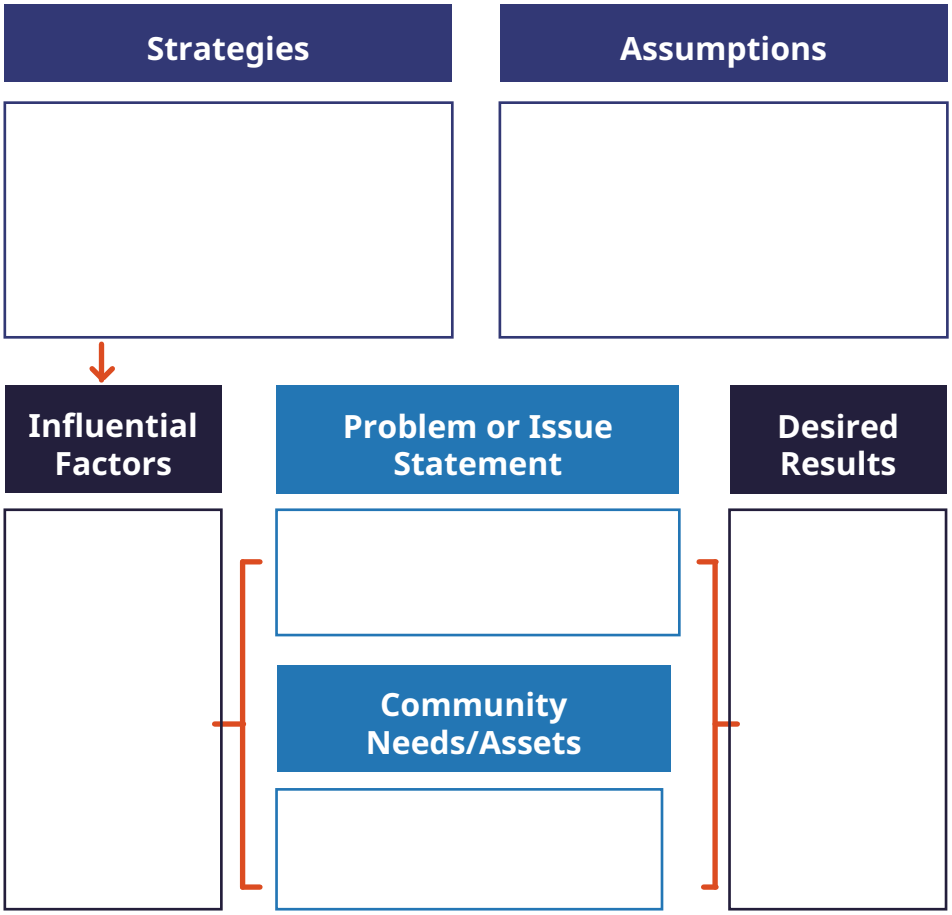
Appendix: Six Sections of a Theory of Change

If you have the digital copy of this book, this appendix contains a form-fillable version of figure 7 available for your personal use.



This book explores over five years of research experience and practice around learning and education systems especially related to Science, Technology, Engineering, and Math (STEM). It is a collection of ideas on how to Communicate with stakeholders to increase Collaboration and impact Convergence. The following collection of articles is based on primary empirical research, which, taken together, spans several years and numerous sponsored research endeavors, presents frameworks for thinking about STEM knowledge transfer and student character building as well as practical suggestions for everyday praxis. Through its pages, the reader will explore strategic models for STEM education and research, analyzing the communication processes and their relationship with language while considering their impact on Trans-Disciplinary Collaboration for innovation.

ISBN 978-987-88-8278-9

MIT EDITORIAL