6-1-2022

Building STEM Teacher Capacity at a South American International School

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Abstract

Although originating in the United States, STEM education has gained acceptance worldwide as an inquiry-based, interdisciplinary approach engaging students in active learning. Despite the ubiquity of STEM—science, technology, engineering, and mathematics, schools face challenges in providing professional development for teachers. This organizational improvement plan addresses a lack of adequate professional development to support STEM implementation at an international school in South America. Based on a constructivist assumption that teachers' beliefs, cultures, and experiences mediate their learning, a mentoring program was selected as the most viable solution strategy. Mentoring provides a pathway for mentees to enact new strategies with their mentors' support promoting reflection and professional growth. This change requires a transformational leadership approach, complemented by distributed leadership practices, to foster relational trust, inspire a change vision, and focus on the collective learning of program coordinators, mentors, and mentees needed to propel the change forward. A change path framework will be employed that awakens, mobilizes, and accelerates change forces toward the eventual institutionalization of the program. This framework, combined with a robust monitoring, evaluation, and communication plan, will incorporate teacher voices and foster commitment at each phase of change. Furthermore, structuring an effective professional development model that includes teachers' prior knowledge, beliefs, language, and culture will promote a shift away from postcolonial patterns in the school context and build teacher capacity and confidence to teach STEM.

Keywords: STEM, professional development, mentoring, postcolonial, transformational leadership

Executive Summary

Chapter 1 discusses the context of this organizational improvement plan at a K–12 international school in South America with a mixed local and expatriate staff. Six years ago, the school began implementing an inquiry-based STEM program from kindergarten through Grade 12, yet providing high-quality professional development continues to be a challenge. STEM instruction requires teachers to have sophisticated pedagogical skills and deep content knowledge to be effective. However, teachers are often unprepared to teach STEM (Kocabas et al., 2020), and many STEM professional development models lack the relevance and continuity needed to build teacher capacity (Affouneh et al., 2020). An organizational congruency analysis applied to the local school context shows a gap between what the school expects from teachers and the professional development structures in place. The current STEM professional development at the school lacks an articulated vision, expectations, and outcomes and is not effectively building teachers' capacity and confidence for STEM instruction.

As the school's director, I have the formal authority to secure resources, set priorities, and implement strategic change. My constructivist approach informs my belief that prior knowledge and experiences mediate teachers' professional growth. This means that any solution must recognize that learning emerges from the process of teachers enacting new strategies and reflecting on their impact. Adding to the complexity of this change are the challenges that educators face as the school shifts between in-person, virtual, and hybrid instruction to respond to the COVID-19 pandemic. This means less time for professional development, reduced readiness for change, and increased staff turnover.

Chapter 2 discusses how a transformational leadership approach that fosters relational trust, inspires vision, and focuses on collective learning will be used to propel the change forward. In addition to transformational leadership, elements from distributed leadership can be

applied to share responsibility between multiple individuals deepening the understanding of change and increasing change readiness (Schulte, 2018). Deszca, Ingols, and Cawsey's (2020) change path model focuses on learning, communication, and strategic orientation in managing evolutionary change. This model provides a pathway for successful change and aids in diagnosing the needed change.

Different solution strategies are evaluated based on the benefits, resources required, trade-offs, and alignment with the leadership approach, with mentoring emerging as the most viable. A mentoring program empowers teachers to take collective responsibility for learning (Martin et al., 2020), stretches leadership over formal and informal roles, and aligns with transformational and distributed leadership approaches (Aspfors & Fransson, 2015). Confirming the gap with evidence will make a case for change and awaken the change recipients. Then, articulating the change plan and involving participants will mobilize key individuals to join the effort. Finally, developing a mentor program as a pilot with clear outcomes and activities will propel the change forward.

Chapter 2 concludes by examining STEM PD practices through a postcolonial lens, which reveals that most external STEM professional development opportunities are U.S.-based and often English-only, thus creating barriers to non-English-speaking staff. Additionally, American pedagogical theory and practice underpin this professional development, limiting its relevance in the South American educational context (Takayama et al., 2016). This exposes inequitable practices at the school, which can be addressed through a mentoring program.

Chapter 3 describes how the chosen change path model aligns with the theoretical framework and is coherent with the contextual forces described in this organizational improvement plan. This change path model guides the implementation of the mentoring program through the awakening, mobilization, acceleration, and institutionalization phases. Next, a discussion of monitoring and evaluation will establish how program theory and logics inform decisions of what evidence will be used and how it will be gathered to monitor implementation. The insights gathered through this process will encourage organizational learning as the program moves from pilot to full implementation.

Chapter 3 concludes by asserting that communication is a significant contributor to successful change. A detailed communication plan is discussed, with three pillars: why change is happening; what will be communicated, for whom and by whom; and how the change will roll out. This communication plan has the goals of encouraging active participation of stakeholders, amplifying teachers' voices, and addressing change readiness.

STEM education requires teachers with a high instructional capacity to provide integrated and inquiry-based learning environments. Mentoring provides a powerful strategy that empowers teachers, leverages their prior knowledge, and builds collective responsibility for teacher growth (Richmond et al., 2017). When combined with an appropriate change model and leadership approaches, this change effort will promote STEM teacher growth and build the confidence and collective responsibility needed to address the challenges STEM teachers face each day.

As next steps and future considerations, it is hoped that educators continue to leverage this pedagogy to overcome the underrepresentation of non-dominant groups in STEM university programs and in the STEM workforce. To do this, teachers will need to build capacity beyond planning and instruction and toward an understanding of the authentic patterns of STEM engagement present in students' lives inside and outside of school. This represents another horizon in STEM teacher instructional capacity and has the potential to shift STEM PD further away from traditional postcolonial paradigms and create new understandings of STEM and STEM PD.

Acknowledgments

I want to thank my academic instructors for guidance along the way, especially Dr. Lowrey, for his patience, critical feedback, and for reminding us to take time for hijinks and shenanigans. To my mom, for every philosopher, there is someone who listens. To my dad, a marathon runner, who taught me that when running uphill, look down and put one foot in front of the other. To my daughter, Luisa, who has also been completing her undergraduate degree and working full time . . . we did it! To my son Daniel: not many people have a passion for learning as you do; you motivated me to stay focused. Finally, to my youngest son, Andrew, who kept reminding me that I could have invested the tuition money in a backyard pool. Sorry, maybe next time.

Most of all, I want to thank my wife, Lina. As a fellow educational leader and scholar, and life partner, you were with me every step of this journey. You listened when I had to talk things out, you gave me feedback, and you were an enormous support. You are a doctoral widow no more!

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Acronyms

AP (Advanced Placement)

CBAM (Concerns-Based Adoption Model)

CoP (Community of Practice)

NCIS (Northern College International School)

OIP (Organizational Improvement Plan)

PD (Professional Development)

PDSA (Plan, Do, Study, Act)

PESTEL (Political, Economic, Social, Technological, Environmental, Legal)

PoP (Problem of Practice)

STEM (Science, Technology, Engineering, Mathematics)

Definitions

Advanced Placement: A program that offers college-level curricula for high school students.

Change Path Model: A framework that assumes that change is complex but predictable and can be managed. The change goes through awakening, mobilization, acceleration, and institutionalization phases (Deszca et al., 2020).

Cognia: An international school accreditation agency that certifies the school and STEM program (Cognia, 2020a).

Communities of Practice: Educators form collective learning groups around a common interest to share experiences, expertise, and resources (Wenger, 2009).

Congruence Model: A model that describes the inputs, outputs, and organizational elements whose congruency contributes to, or impedes, effectiveness (Nadler & Tushman, 1997).

Constructivism: A theory of knowledge and learning where individuals' understanding of reality is a continuous and socially mediated process (Pfadenhauer & Knoblauch, 2018), where knowledge is generated and exchanged, and meaning is developed through interaction (Karataş-Özkan & Murphy, 2010).

Expatriate Teachers: Teachers at international schools who are on overseas-hired contracts, often from the United States, Canada, and the U.K. (Mancuso et al., 2010).

Duck's Change Curve: A model that describes individuals' emotional reactions when organizations pass through the five stages of change: stagnation, preparation, implementation, determination, and fruition (Duck, 2001).

Hybrid Learning: Instructional model where some students are physically in the classroom while others connect virtually.

International School Dualities Framework: A framework to understand the competing agendas, pragmatic versus idealistic, in international education (Keller, 2015a).

Postcolonialism: The global condition where cultural, political, and economic arrangements result from European colonialism (Tikly, 1999).

Realist Evaluation: An evaluative approach that assumes multiple contextual factors also must be monitored (Porter, 2015).

Retroactive Resistance: After initially supporting the change initiative, individuals lose enthusiasm when the extent of change becomes apparent (Duck, 2001).

STEM: An inquiry-based approach that integrates the content areas of science, technology, engineering, and mathematics and engages students in active learning environments (NCIS, 2018).

STEM Mentoring Program: Experienced STEM teachers supporting teachers new to the school or new to STEM instruction.

STEM Teacher Professional Growth: A model that illustrates how teacher professional growth is a nonlinear process emerging from the enactment and reflection of the external domain, personal domain, domain of consequence, and domain of practice (Clarke & Hollingsworth, 2002).

Translanguaging: A theoretical and instructional approach that does not separate languages but offers multilingual spaces that optimize learners' prior knowledge base and cultural background (Cenoz & Gorter, 2021).

Transnational Space: The space where expatriate and local actors interact and create sociocultural ties independent of national borders (Tarc & Tarc, 2015).

Virtual Learning: Instructional model where students connect to their teacher through video conferencing platforms to continue school when in-person classes are not possible.

Chapter 1: Introduction and Problem

STEM originated as an American policy response to increased global and workforce competitiveness 20 years ago and has now been adopted by schools worldwide (Keratithamkul et al., 2020; Shernoff et al., 2017). Five years ago, Northern College International School (NCIS, a pseudonym), a not-for-profit K–12 international school in South America, implemented STEM education. STEM is science, technology, engineering, and mathematics taught in an inquiry-based, interdisciplinary approach that engages students in active learning (NCIS, 2018). This approach to education aligns with my constructivist views and is why I am a proponent of STEM implementation at my school.

Full implementation of STEM at NCIS remains elusive. In this chapter, Nadler and Tushman's (1997) congruency model will be used to identify gaps between the current and desired state of STEM education at NCIS. This analysis shows a lack of congruency between the type of instruction teachers are expected to implement and the current STEM professional development (PD) structures. Adding to this complexity are the competing agendas in international education and at NCIS. A dualities framework will illustrate how practices align with pragmatic or idealistic outcomes and how STEM spans both dualities and why this shapes the organizational aspirations of NCIS (Keller, 2015a).

Despite the complexity of this change effort, my position as school director and my cultural competency provide me with the agency and influence to generate change. A PESTEL analysis and a review of the STEM PD literature, data, and postcolonial patterns identify the forces that frame the problem of practice (PoP) and lead to a compelling vision for change. This chapter concludes with a thorough assessment of change readiness, which shows uneven readiness on an individual and school level to address the change needed in this organizational improvement plan (OIP). The following section outlines how the school's history, competing agendas within the organization, and the school's aspirations frame the context of this OIP.

Organizational Context

This section discusses how school history, demographics, governance model, and the COVID-19 pandemic are essential factors in this change effort. Also, how two competing agendas—pragmatic and idealistic—compete and create tension in international schools (Keller, 2015a). A dualities framework will be applied to understand how these agendas drive NCIS's aspirations and STEM implementation. This section concludes with a discussion of existing STEM program leadership practices and structures and how they contribute to the selection of transformational and distributed leadership approaches.

Context

Context greatly influences leadership and leadership decisions (Hallinger & Leithwood, 1996). For example, the school's 60-year history in the community, the governance structure, and the impact of COVID-19 on the school and staff are all contextual factors that shape the organization and influence this OIP.

History of NCIS

Northern College International School was founded in the mid-20th century to provide bilingual (English–Spanish) education and promote understanding between local, U.S., and other international cultures (NCIS Statutes, 2017). The trend in international education in the 1960s was to promote transnational and international relations (Sylvester, 2005), and NCIS was no different. As the world globalized, NCIS, like many international schools, responded to the desire of parents to attain an education that permits mobility and competitiveness for their children (Keller, 2015a). The school offers a dual host country and U.S. high school diploma, including an Advanced Placement (AP) and STEM program. In addition, the school has been accredited since 1994 by Cognia, an international school accreditation agency. International accreditation, the U.S. diploma program, and STEM education, while widely seen by the students and families as beneficial, can also be evidence of NCIS's entanglement in certain postcolonial practices (Takayama et al., 2016).

Demographics

Currently, NCIS has 780 students, from prekindergarten to high school. Most of the students are from host-country families, with only 10% from other countries (Search Associates, 2020). Of the 100 instructional staff, 25 are foreign-hired and 75 are locally hired; 13% of the instructional staff speak English only, 59% are bilingual (English–Spanish), and 28% speak Spanish only. The turnover rate of expatriate staff fluctuates between 27% and 38%, slightly higher than the regional average (Desroches, 2013). The turnover rate of local teachers is much lower. Near to the NCIS campus is an international medical centre, and the city is the headquarters of the national petroleum company. Many professionals from these two STEM-related industries have their children at NCIS, which may account for the support for STEM from parents and illustrates how closely the local economy is tied to the global one.

The effort to implement STEM enjoys high support across all stakeholders. For example, the NCIS board of directors views STEM as a differentiator within the local school market. Parents see STEM as making their children more competitive in the workforce, and teachers and students see STEM as a rigorous program that engages students in authentic learning experiences (Rojas, 2019). School history, demographics, and governance shape NCIS's aspirations and context. However, in March 2020, the pandemic altered how instruction was delivered in schools worldwide.

Impact of COVID-19

This OIP is being carried out two years into a global pandemic. COVID-19 protocols require modifications to schedules, programs, and school routines, impacting the lives of students, staff, and parents. During the 2020–2021 school year, newly hired expatriate teachers could not enter the country, complicating attempts to onboard staff. Turnover of expatriate staff increased 20% over past years' averages. Mental health inventories applied to teachers showed that long work hours and inability to manage time demands were challenges, and 40% of staff reported anxiety symptoms (e.g., loss of sleep, loss or increase of appetite). As the school moves from virtual to in-person learning, and sometimes a hybrid of the two, efforts at change need to consider burdens on teacher time, mental stress, and turnover, and how these factors and other forces frame this OIP. Besides contextual factors there are theoretical frameworks that reveal forces that drive the organization.

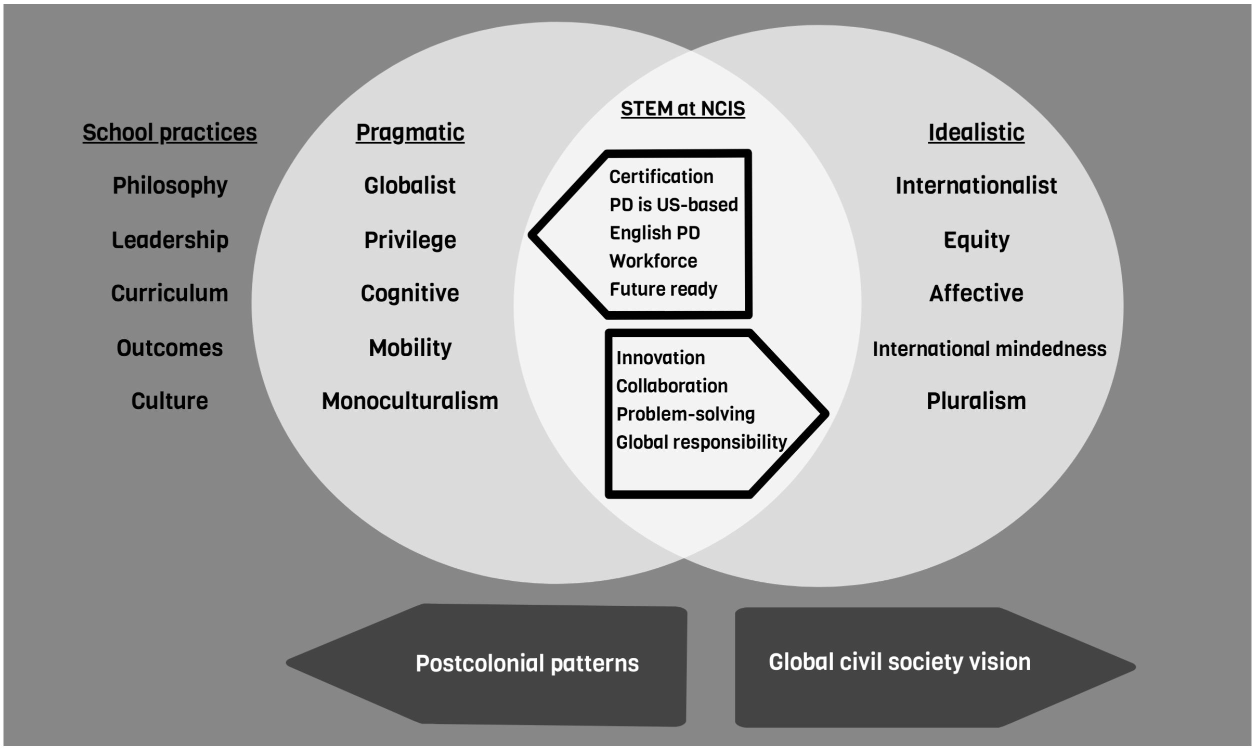
Theoretical and Conceptual Frameworks that Drive the Organization

Competing agendas in international education aligning with pragmatic or idealistic outcomes create dualities[1] and increase complexity in change efforts. Understanding these agendas will help leaders navigate these, often competing, discourses (Keller, 2015b). Figure 1 illustrates how school constructs such as philosophy, leadership, curriculum, outcomes, and culture align with pragmatic or idealistic outcomes.

[1] The plural form of duality is used since it refers to more than one school construct or practice.

Figure 1

Dualities in International Education



Note. Adapted from Keller, D. (2015a). *International education: Stakeholder values and perceptions.* [The World View Project]. https://www.ibo.org/contentassets/4ccc99665bc04f3686957ee197c13855/research---executive-summary---international-education---stakeholder-values-and-perceptions---en.pdf

Idealistic ideology is grounded in global civil society theory, which views education as promoting the public good (Delacruz, 2005). At the heart of the idealistic agenda is that international cooperation, international-mindedness, and global citizenship are good for the world (Tarc, 2019). With the broad purposes of a peaceful world, understanding between nations, and a responsible world citizenry, the idealistic agenda of education purports to develop these concepts in youth (Keller, 2015a) and puts it in contrast with the pragmatic ideology.

Pragmatic ideology is based on a postcolonial assumption that the value of international education is a means to access academic and economic opportunities in Western countries or transnational corporations (Stier, 2004). This global competition mindset includes attaining an international diploma, acquiring English-language proficiency, and focusing on global competitiveness (Haywood, 2015; Weenink, 2008). Pragmatic and idealistic agendas create dualities within international schools, often giving rise to tensions as different groups advocate for pragmatic or idealistic outcomes (Keller, 2015a). Distinct ways of seeing the world underpin both pragmatic and idealistic agendas.

Postcolonial and Global Civil Society Dualities

These dualities represent tensions between postcolonial entanglements and a vision of global civil society. Postcolonial theory states that globalization is the imposition of Western countries' political and economic agendas, benefitting rich nations to the detriment of poorer ones (Hébert & Abdi, 2013). This is evidenced by international education being used to expand superpowers' sphere of influence during the Cold War (Tsvetkova, 2008) and the increase in number of international students, along with globalization, in the 21st century (Tarc, 2019). Nguyen et al. (2009) point out that when postcolonial patterns are left unexamined in schools, educational reforms aligned with global civil society theory are undermined.

Global civil society theory places value on an international order beyond nation-state boundaries to promote peace and democracy in the global sphere (Bartelson, 2006). International school communities, including their teachers and philosophies, are linked by their translocality and ties in this transnational space (Tarc & Tarc, 2015). This means that school programs and implementation decisions may align with idealistic or pragmatic agendas or span both. This framework illustrates the tensions and competing agendas that exist in the broader field of international education, and which may also affect how STEM is implemented on a school level.

STEM Spans Dualities

Although STEM concepts and meanings differ as it is enacted in different settings, many STEM practices and outcomes align with pragmatic and idealistic agendas, as shown in Figure 1. At NCIS, the definition of STEM includes developing "future-ready students . . . to succeed in an ever-changing world" (NCIS, 2018, p. 3). This concept of success is drawn from a pragmatic agenda that sees STEM as a means to achieve global competitiveness. For example, the local national government has increased spending on digital learning with the explicit goal of engineering a more tech-savvy workforce (OECD, 2019).

However, as enacted at NCIS, STEM also focuses on STEM classroom projects that promote social responsibility and environmental stewardship, which align with idealistic outcomes. For example, a group of elementary students recently won an international innovation award for designing, building, and programming a robot to deliver medication to COVID-19 patients (El Tiempo, 2022). This is an example that STEM includes objectives oriented toward global citizenship, or the public good, situating practices in the idealistic paradigm (Delacruz, 2005). STEM is an approach to education that can span both pragmatic and idealistic dualities, which helps to understand NCIS's organizational aspirations and practices.

Organizational Aspirations

The school aspires to progressive ideals, and STEM education is a way that the school aims to achieve this vision. These ideals influence the decisions to adopt STEM and NCIS's staffing and leadership structure.

STEM Education

North College International School promotes international understanding, an English education, and the attainment of a U.S. diploma (NCIS Statutes, 2017). A STEM education promotes progressive education, social responsibility, global mindedness, and the lifelong learning that parents and students value (Rojas, 2019). These broad school aspirations led to the introduction of the NCIS STEM program, which, as mentioned above, spans pragmatic and idealistic agendas.

STEM Leadership Structure

STEM requires a high level of collaboration across disciplines (Bush et al., 2020); hence the program's leadership structure was designed to follow this same principle. The school has two STEM coordinators, one in charge of the program from kindergarten to Grade 5 and the other from Grade 6 to 12. They also cochair a schoolwide STEM committee made up of experienced STEM teachers. The STEM coordinators work with the school director and section principals to review policy, examine data, and engage in long-term planning on strategic initiatives related to STEM, such as PD. This leadership structure reflects an emerging distributed leadership model where decision-making is shared between individuals who may, or may not, hold formal leadership positions (Spillane, 2006). The following section will examine my leadership position as school director of NCIS and how it shapes decisions taken for this OIP.

Leadership Position and Lens Statement

This section addresses my positionality, agency, power, and influence within the context of this OIP. Furthermore, it outlines how my constructivist philosophy influences my selection of approaches to leadership, learning, and other frameworks selected for this OIP.

Positionality

My identity as an expatriate living in a Latin American country influences my positionality. Kezar (2010) states that positionality is based on identity, which is fluid and dynamic and affects how individuals socially construct their world. The intersection of multiple identities, such as race, gender, and class, reinforces individual perspectives and impacts leadership beliefs and practices. I am a mixed-race Canadian educator and have spent most of my career teaching and in leadership positions in Latin America. My time in Latin America and at international schools has allowed me to interact with people from different countries. This interaction, along with my experience growing up in a bicultural family, has given me the ability to function effectively in a different culture, what Apud et al. (2006, p.526) call “cultural competence.” This experience allows me to understand the cultural dimensions at play in my organization and how to navigate them, thus increasing my agency.

Agency

Although my identity shapes my positionality, my agency will largely determine my ability to influence change. Bandura (2006) describes agency as an individual’s intentional actions that respond to and shape the context. My agency derives from my formal authority and responsibility as director. Research suggests that when leaders have agency, they can better enact innovative change (Greany & Waterhouse, 2016) even when the change is complex (Wolfgramm et al., 2015). Despite this agency, some constraints exist; annual budgets, major investments, and strategic decisions are all subject to board approval. Thus, although my agency to affect change is significant, there are still checks and limits on the formal powers of the school director. In addition to my positionality and agency, my leadership lens informs the decisions taken throughout this OIP.

Personal Leadership Lens

Leaders’ personal lenses and philosophies determine how they see the world and influence their cognitive processes and leadership practices (Tickle et al., 2005). Constructivism shapes my view of education and leadership. I believe that the sociocultural context affects how and what people learn (Pritchard, 2017). Learning occurs in a space mediated by the learners’ beliefs, experiences, and culture, affecting their knowledge construction (O’Dwyer, 2018).

Constructivism can also be used as a lens to examine how teachers learn their craft through social interaction with other teachers leading to professional growth (Irby, 2020). Constructivism not only shapes my beliefs about teacher learning, it also has led me to see STEM education as a powerful vehicle for student learning.

I support STEM because it is an interdisciplinary approach that encourages students to see knowledge as contextualized and integrated (Holmlund et al., 2018). This pedagogy promotes an active, collaborative process where knowledge is discovered and teachers seek to engage learners in tasks with implicit worth (Nadelson et al., 2013). The contextualized nature of knowledge, the collective approach to inquiry, and the inquiry-based nature of STEM education make it a pedagogy situated in a constructivist lens of education (Adams, 2006; Kritt, 2018; Shapiro, 2000).

This constructivist lens also determines my selection of transformational leadership as an approach to accelerate change. Individuals' understanding of reality is continuous and socially mediated (Pfadenhauer & Knoblauch, 2018). Knowledge is generated and exchanged, and meaning is developed through interaction (Karataş-Özkan & Murphy, 2010). Thus, leaders must focus on constructing a shared vision and building consensus among personnel (Mitchell, 2019). Transformational leadership embraces this by inspiring followers, encouraging intellectual growth, and attending to their needs as they work through the transformation process (Banks et al., 2016). Furthermore, transformational leaders inspire followers to achieve the organization's vision, which predicts work motivation, satisfaction, and innovation (van Dierendonck et al., 2014). There are additional contextual reasons why transformational leadership is an appropriate choice.

The NCIS context factors inform my selection of transformational leadership. All stakeholder groups value STEM education (Rojas, 2019), making building a shared vision more achievable. Transformational leadership aims to set a vision and raise followers' consciousness about purpose (Drysdale et al., 2016). My 11 years at the school have given me an understanding of the cultural dimensions in the context. This experience can be leveraged as a transformational behaviour to deepen the connection with followers (Burns, 1978). The constructivist approach to this OIP, the school context, and my positionality contribute to selecting transformational leadership to address the problem of practice (PoP).

Leadership Problem of Practice

The PoP will articulate the gap between the current state of STEM PD and the future state that will emerge from the enactment of solution strategies outlined in this OIP. The following section describes the PoP inductively, starting with the issue, then the measurable effects and symptoms, my agency as school director, and culminating with the PoP statement.

Problem of Practice

Despite international certification of the STEM program, achieved in 2018, it is evident in survey and classroom observation data that PD structures at NCIS lack the robustness to provide teachers with the pedagogical skills to build their capacity and confidence in STEM instruction. This is not surprising considering that effective interdisciplinary and inquiry-based instruction requires a high level of teacher expertise (Duschyl & Bybee, 2014; see also Lesseig et al., 2016; Ufnar & Shepherd, 2019). Provisioning effective PD is a common challenge for schools with STEM programs, and a lack of relevance, time, teacher input, continuity, and peer support are well documented in the literature (Affouneh et al., 2020; Dan & Gary, 2018; Kocabas et al., 2020; Nadelson et al., 2013).

There are two measurable effects of this problem. First, classroom observation scores on *active learning*—a key element of STEM learning environments (Holmlund et al., 2018)—have increased only marginally post–STEM implementation (see Appendix A). Likewise, observation scores on *digital integration* have shown zero increase post–implementation. The second effect of this problem is clear from teacher perception data. Annual staff surveys that ask teachers their opinion on different aspects of school show that continuous PD is one of the lowest-rated items (see Appendix B). Evaluations of school STEM workshops show that 71% of teachers desire PD more specific to the grade level or subject they teach.

Three practices may be causing the effects of this problem. First, lack of policy may limit the impact of current PD on addressing challenges that teachers face implementing STEM. Currently, little written policy governs the STEM PD program's structure, vision, and outcomes. The literature strongly suggests that without a clear purpose, targeted results, and empirically validated approaches to teacher learning, PD effectiveness will be limited (Guskey, 2003; Yoon et al., 2007). Second, NCIS relies on U.S.-based, expert-driven sources for STEM PD. This privileges Western ways of seeing and knowing the world and marginalizes local concepts of knowledge (Hébert & Abdi, 2013). These sources offer mainly English-only PD, creating barriers to 28% of NCIS staff with limited English abilities. Finally, the current practice relies on one-off, workshop-based models of STEM PD. As a result, teachers have little opportunity to engage in continuous PD shown by meta-studies to promote professional growth (Yoon et al., 2007).

The formal authority that I have as school director of NCIS and my cultural competence developed over 18 years of residency in South America give me the agency to address this problem. Since I work closely with the STEM coordinators in planning and leading the program, I will employ transformational leadership approaches that focus on follower capacity building and distributed leadership to catalyze and sustain change.

This OIP addresses the lack of effective STEM PD by incorporating teacher beliefs, experience, culture, and language in professional learning. This integration will precipitate a shift away from the U.S.-based, English-only workshop model, disentangling practice from postcolonial patterns, and providing teachers with the knowledge and skills to face the challenges of teaching STEM at NCIS. Before advancing with the solutions, there is a need to discuss how the problem is framed in the context of this OIP.

Framing the Problem of Practice

There are three main reasons NCIS needs to change its approach to STEM professional development. First, current STEM PD is not meeting the instructional needs of teachers. Second, the PD adheres to an expert-driven model that may not be relevant to the NCIS context. Third, teacher turnover means that each year new STEM teachers require induction. A PESTEL analysis will examine the factors that impact the PoP, and a review of internal school data will provide evidence that change is needed. This section also asserts that some practices at NCIS, align with pragmatic outcomes and reproduce postcolonial patterns. Understanding the contextual forces framing the PoP will provide more effective solution strategies.

STEM at NCIS

Several authors attribute the creation of the acronym STEM to the U.S. National Science Foundation to convey the interdisciplinary approach to teaching these subjects (Mohr-Schroeder et al., 2015). However, as STEM is enacted in the different U.S. and international contexts, the meaning of STEM varies (Kocabas et al., 2020). At NCIS, STEM is an "inquiry-based, integrated pedagogy designed to develop future-ready students with the innovative mindsets and skills necessary to solve problems and succeed in an ever-changing world" (NCIS, 2018, p. 3). Approximately 3 years before writing this OIP, NCIS began implementing a STEM program from kindergarten through high school. Teachers at NCIS aim to integrate curricular areas through STEM projects that encourage students to see knowledge as interconnected, promote active learning, and encourage collaboration. Nevertheless, challenges to adopting STEM pedagogy exist.

Despite STEM program certification achieved in 2018, full implementation across all STEM curricular areas and grade levels remains elusive. This may be due to the gap between the skills and knowledge teachers are expected to teach and the effectiveness of the current STEM PD structures. The current STEM PD model is a workshop-based model that assumes that teacher growth is linear, with teacher in-service training leading to a change in classroom practices. For the past 2 years, STEM experts from the United States have visited NCIS to conduct 2-day STEM teacher institutes. Much emphasis was put on the training, with little follow-up on implementation and evaluation of results, two elements shown by research to increase the likelihood that PD will change professional practice (Bush et al., 2020). Results from surveys of STEM PD and evaluations of activities suggest that teachers desire more relevant learning that addresses the challenges that teachers face in the classroom. Fortunately, a large body of research identifies factors that contribute to effective PD.

Recent Literature on STEM PD

The ubiquity of PD in schools has generated a substantial amount of literature on the topic. Professional development contextualized in teachers' daily work is more impactful (Castro & Superfine, 2014; Guskey, 2009). Meta-studies have found that the duration and intensity of the PD have a positive effect on outcomes (Yoon et al., 2007). Promoting collaborative practices, where educators are collectively engaged in inquiry, generates better outcomes (Hilton et al., 2015; Mincu, 2015). Additionally, researchers found that purposefulness in program structure, targeted outcomes, and using empirically validated theories of learning yield better PD results (Guskey, 2003; Yoon et al., 2007). Similar findings are observed in STEM PD.

When looking specifically at STEM PD many effective practices build on participant experiences and backgrounds, situating them in a constructivist approach. For example, Du et al. (2019) found that sustained and collaborative STEM PD that addressed the challenges and experiences teachers faced daily increased teacher capacity and improved instructional strategies. Similarly, the collective participation of mentors and mentees in PD increased new teachers' confidence in teaching STEM (Nesmith & Cooper, 2019). Pairing experienced STEM teachers with new STEM teachers leveraged both teachers' backgrounds and knowledge, leading to increased teacher capacity (Kilpatrick & Fraser, 2019). Conversely, scholarship has found that limited teacher input in PD program development and a lack of peer support limit its effectiveness (Affouneh et al., 2020; see also Dan & Gary, 2018; Nadelson et al., 2013). In addition to the research, contextual factors on macro, meso, and micro levels frame the PoP.

PESTEL

A PESTEL—political, economic, social, technological, environmental, and legal analysis reveals that several factors cascade from macro to meso to micro levels and impact the PoP (see Appendix C). First, the host country's national government aims to increase its global competitiveness by increasing school technology education programs (OECD, 2019). Although these government-led school reform efforts do not affect NCIS directly since it is an independent school, national discourse can influence classroom practices (Schulte, 2018). This meso-level factor contributed to implementing a STEM program in 2016, which led to certification in 2018. Second, staff turnover, which has increased since the COVID-19 pandemic, puts more pressure on the school to build teacher STEM capacity since there is a continual need to support new STEM teachers. Third, the adoption of STEM education in schools worldwide means many different approaches and definitions, which leads to implementation inconsistency (Schulte, 2018). Finally, most STEM PD is U.S.-based, and available in English only, creating barriers to non-English-speaking educators. National policy, school strategic initiatives, staff turnover, and a paucity of Spanish-language STEM PD are the macro, meso, and micro factors influencing the PoP. Additionally, postcolonial patterns exist in international education and STEM that impact the PoP.

Postcolonial Patterns

Major European powers colonized South America, and these patterns persist in government, culture, language, and education. At the beginning of the 20th century, the United States enacted a policy that set itself above and apart from Latin American countries, opening the door to intervention and hegemony in the Americas (Ryan, 1999). In Chapter 2, a fuller description of these postcolonial forces will be discussed. To frame the PoP, it is critical to understand that explicit outcomes of education at NCIS, such as granting a U.S. diploma, English-language proficiency, and STEM education, are U.S.-centric outcomes situated in the pragmatic agenda of international education (Carter, 2017; Keller, 2015a). Nevertheless, these outcomes have a high level of desirability and support from NCIS parents and students (Rojas, 2019).

Postcolonial patterns can also be found in STEM education. Science often privileges Western ways of seeing and knowing the world and delegitimizes other epistemologies (Hébert & Abdi, 2013). Although there have been efforts to decolonize science education in some secondary schools (see Gandolfi, 2021), there is no such debate at NCIS, thus far. This is a problem since the valorization of different forms of knowing, doing, and being mediate student and teachers' engagement with STEM education (Rahm, 2014). Moving away from a U.S.-based STEM PD model is imperative for this OIP and is supported by internal and external data.

Internal Data

The school accreditation agency Cognia, which also certifies the STEM program, requires continuous data collection to demonstrate program effectiveness and school improvement efforts. Using data that the school is already collecting ensures ethical considerations since they align with learner needs, institutional priorities, and the promotion of collective inquiry (Lofthouse et al., 2012). Classroom observation data (see Appendix A) and annual surveys of NCIS teachers (see Appendix B) are two sources of data. Additional advantages of using these data are they provide a longitudinal comparison, can be norm-referenced, and are collected using a research-supported observational tool (Li et al., 2020). Furthermore, trained NCIS staff conduct the observations, detaching the data collection from possible researcher agendas, biases, and positionality (Scott, 2012). An analysis of these data will be discussed in the critical organizational analysis section of this OIP. In addition to internal data, examining external data will provide further insight into the PoP.

External Data

Country-specific PISA data are available through the OECD (2022) and suggest that the national scores for students in the country in math and science are below the test average. Male students outscored females in the math test by one of the largest differences in Latin America. On the 2018 Teaching and Learning International Survey (TALIS), a higher percentage of local country teachers reported the need for more PD on digital technology (OECD, 2022). Based on this evidence, the struggle to adequately prepare teachers for STEM is a problem at NCIS and on a national level.

The evidence presented in this section demonstrates that STEM education is challenging to implement and accompanying it with robust PD that supports teachers is not easy. A PESTEL analysis shows the micro, meso, and macro factors that frame the PoP. The current STEM PD does not have an articulated vision, expectations, or clear outcomes. Teachers express the desire for more relevant PD, and teacher turnover creates a need for more effective PD for new STEM teachers. Additionally, the existing PD does not view teachers as active participants in their growth and aligns itself with a U.S.-based pedagogy that may not be relevant to NCIS and may further entangle the school in postcolonial practices. These are strong reasons that change is needed to improve STEM instruction and they also inform the generation of guiding questions for this PoP.

Guiding Questions from the PoP

In this OIP, two significant challenges emerge from the main PoP: teacher turnover and navigating competing agendas; the literature substantiates both as potential barriers to school quality. Teacher turnover in international schools has negative implications for learning (Mancuso et al., 2010), and conflicting agendas in international education impede change efforts (Keller, 2015a). Potential lines of inquiry that stem from the problem involve issues of equity, language, PD reorientation, teacher turnover, and existing dualities.

Teacher Turnover

Teacher turnover rates in international schools tend to be higher than rates in the United States. Mancuso et al. (2010) claim that 16% of the expatriate teaching staff at international schools turn over each year, and Desroches (2013) found that in South America, the average is 28%. Over the past 4 years, the turnover rate at NCIS has varied between 27% and 38% among expatriate staff. The highest turnover rate occurred during the past year, possibly related to hardships brought on by the pandemic. When teachers depart the school, they effectively take their knowledge and skills with them (Mancuso et al., 2010). Recruiting new staff with the same level of STEM expertise and is a challenge. This turnover means that unless teachers have ample experience in STEM instruction, the learning curve for new staff is steep.

Navigating Dualities

International schools are complex organizations and are places of intense social, emotional, and dynamic interplay that impact curriculum and PD (Caffyn, 2018). In this contested space, stakeholders may exert influence to advance a particular agenda. For example, many educators see idealistic outcomes as desirable benefits of international education (Baily, 2015) and may be reluctant to promote pragmatic activities that counter their idealism (Stier, 2004). At NCIS, shifting away from U.S.-based, expert-driven PD to a model that recognizes teachers' prior beliefs, culture, and language may face opposition from those accustomed to the status quo. Case in point: Cognia, the agency that accredits the STEM program, privileges course-based PD models (Cognia, n.d.), even though the empirical support for job-embedded, collaborative, and continuous PD is more robust (Castro Superfine & Li, 2014; Hardy, 2010). When different stakeholder groups value different outcomes, these dualities create challenges for leaders who wish to engage a diverse community in the change effort. Navigating dualities and teacher turnover are two themes that generate lines of inquiry.

Lines of Inquiry

There are two emerging lines of inquiry.

- Will distributing leadership responsibility and increasing teacher participation in STEM PD design lower annual teacher turnover rates?
- Will including teacher participation in the design of STEM PD allow for incorporating their background, beliefs, and culture, disentangling NCIS from postcolonial practices and increase equity at NCIS?

These lines of inquiry stem from the main PoP and will influence the leadership-focused vision for change.

Leadership-Focused Vision for Change

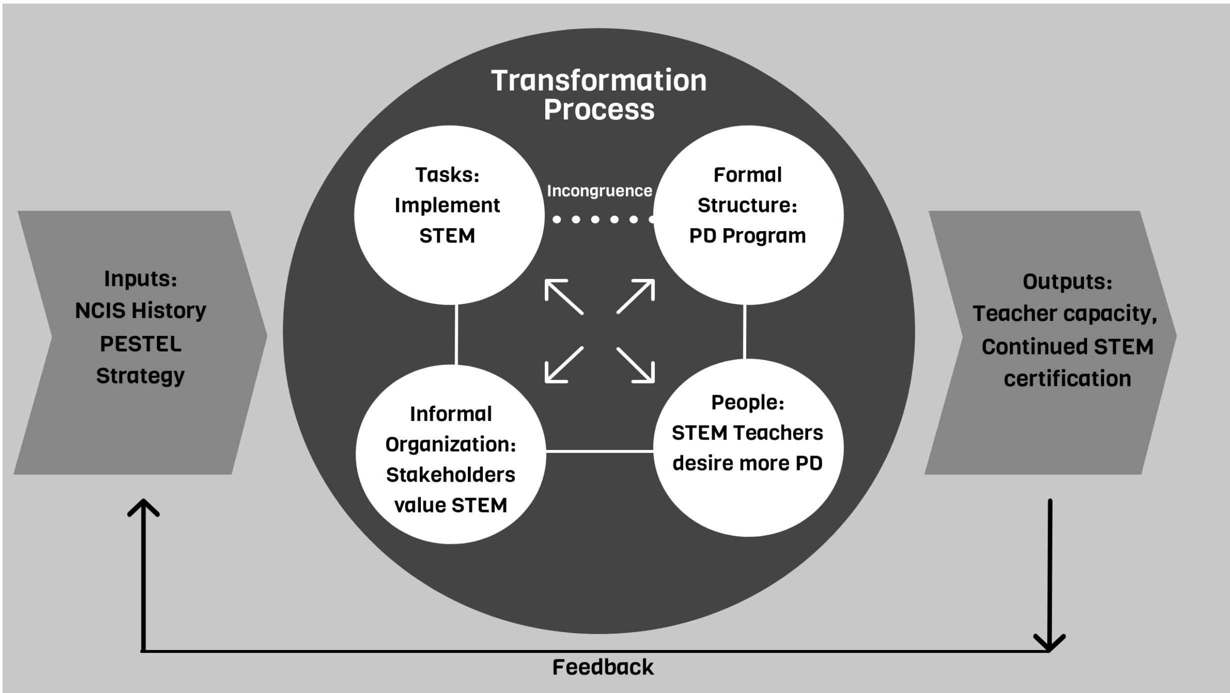
The vision for change is to build the structures that develop teacher capacity and confidence to implement STEM education at NCIS. Nadler and Tushman's (1997) congruence model provides a framework to identify the inputs, the organizational elements, and the gaps between these components. This assessment will identify three priorities for change: articulating a clearer vision for STEM PD outcomes, focusing on the pedagogical skills contextualized in teachers' daily work, and promoting a process of enactment of new practices and reflection to stimulate professional growth. Finally, four internal and external drivers will be introduced that can accelerate the change effort of this OIP.

Organizational Congruence Model

Change requires the application of frameworks and models that permit the understanding of the fundamental causes or drivers of performance and the relationship between them (Sabir, 2018). This OIP will use the organizational congruence model to identify the gap between the current and future state (see Figure 2). This model is a diagnostic tool that examines the complexities of the interdependence of structures, processes, capabilities, culture, and performance (Seong et al., 2015). The congruence model recognizes how inputs are transformed by the elements of the tasks or work, the formal structures, the informal culture, and the people and how these elements interact, complement, and are congruent to assure institutional effectiveness.

Figure 2

Organizational Congruence Model



Note. Nadler, D., & Tushman, M. (1997). *Competing by design: The power of organizational architecture.* Oxford University Press.

Inputs

Inputs are transformed by the organization into the outputs and include the organization's history, the environment where the organization exists, and the strategy employed (Nadler & Tushman, 1997). Since NCIS's history and context, including a PESTEL analysis, were discussed previously, this paragraph will focus on strategy and resources. In 2020, NCIS launched a new strategic plan that involved progressive education as one of its significant pillars (NCIS, 2021). The specific outcomes included an exemplary STEM program, developing students' future-ready skills, and providing pathways for students to enter STEM university programs. Therefore, a dedicated STEM budget area was created to ensure funds for staffing, PD materials, and certification costs. Furthermore, the school maintains two formal partnerships with

US-based STEM organizations that provide PD. These inputs are then transformed by the elements of tasks, formal structure, informal organization, and people to produce desired outputs.

Tasks

Since the organizational history, context, and justification for STEM adoption at NCIS have already been discussed, this paragraph will discuss the transformation process. When congruent with other components, the work carried out by individuals or teams contributes to a successful organization (Nadler & Tushman, 1997). Northern College International School aspires to offer progressive education, and the fully implemented STEM program from kindergarten through Grade 12 is a crucial factor in achieving this. Therefore, the sophisticated knowledge and skills that STEM teachers need to implement this program are the main drivers of the task component and the focus of this OIP.

Formal Structure

The formal organization establishes strategic objectives, management systems, roles and responsibilities, and other structures that allow for effective institutional performance (Nadler & Tushman, 1997). The absence of an articulated STEM PD policy is a symptom of a lack of formal structures. When the policy is incomplete, practitioners imprint their conception, knowledge, and realities, leading to inconsistent implementation (Arafeh, 2014). These are symptoms of a gap between what the organization expects its teacher to know and what they are able to do—the formal structures do not support the development of this professional capacity. More purposefulness in structuring PD programs—with targeted outcomes and based on empirically validated theories of teacher learning—will yield better results (Guskey, 2003; Yoon et al., 2007).

Informal Organization

The informal organization includes the culture, politics, values, behaviour patterns, and norms (Sabir, 2018). The STEM certification report commended NCIS on establishing the program's vision and learning culture, which reflected a STEM identity and supportive environment (Cognia, 2018). These behaviour patterns show that teachers value a STEM education and its vision while simultaneously desiring more PD.

People

The role of the people and their relationship to each other and the organization's culture, work, and structure are central to the people element. A recent survey of NCIS teachers indicated that 71% of respondents desired additional STEM PD, suggesting that current practices fall short of teachers' needs. Misalignment exposes a symptom of a second gap: developing better pedagogical skills essential for teacher professional growth.

Outputs

The group and individual outputs of the organization are crucial elements since they exist as the end of the process but must be used to inform the input and transformation processes. The primary organizational output is the full implementation of the STEM program across grade levels and subject areas and building teacher instructional capacity is vital for this output. This analysis suggests that a lack of congruency in the areas of task and structure impede the successful achievement of the desired output. To address this, three change priorities will be identified.

Change Priorities

Three priorities emerge from the organizational analysis. The first is the need to address a lack of articulated STEM PD policy, where none currently exists. The second is to define the scope of STEM PD, focusing on the pedagogical skills that teachers need to plan, instruct, and assess STEM. The final priority is to promote a professional growth model that allows teachers' backgrounds, beliefs, cultures, and language to mediate the learning.

Policy Articulation

The school expects teachers to implement high-quality STEM instruction without an articulated STEM PD policy. Much research suggests that purposefulness in program structure yields better results (Guskey, 2003; Yoon et al., 2007). Policy construction that promotes stakeholder participation will increase sensemaking and STEM teacher capacity (Affouneh et al., 2020; Castro Superfine & Li, 2014; Guskey, 2009). STEM PD policy accessible to Spanish speakers will increase Spanish-speaking teachers' learning opportunities and agency (Briceño et al., 2018, Guerrero & Guerrero, 2008). For these reasons, the policy must articulate vision, expectations, and outcomes and determine STEM PD's scope.

Scope of STEM PD

A second priority addresses the gap between the task and formal structure elements. Teachers must implement STEM, yet the provided PD is insufficiently addressing the challenges they face as they implement STEM instruction. Conversations with select STEM teachers and annual staff surveys identified two areas that current PD is not addressing: skills for interdisciplinary instruction and PD aimed at new STEM teachers (see Appendix B). Research shows that a lack of teacher knowledge in interdisciplinary instruction impedes instructional effectiveness (Lesseig et al., 2016) and PD for new teachers builds their confidence and effectiveness (Nesmith & Cooper, 2019). Therefore, a STEM PD program that targets these two areas in an effective learning environment will address this gap.

STEM Teacher Growth Environment

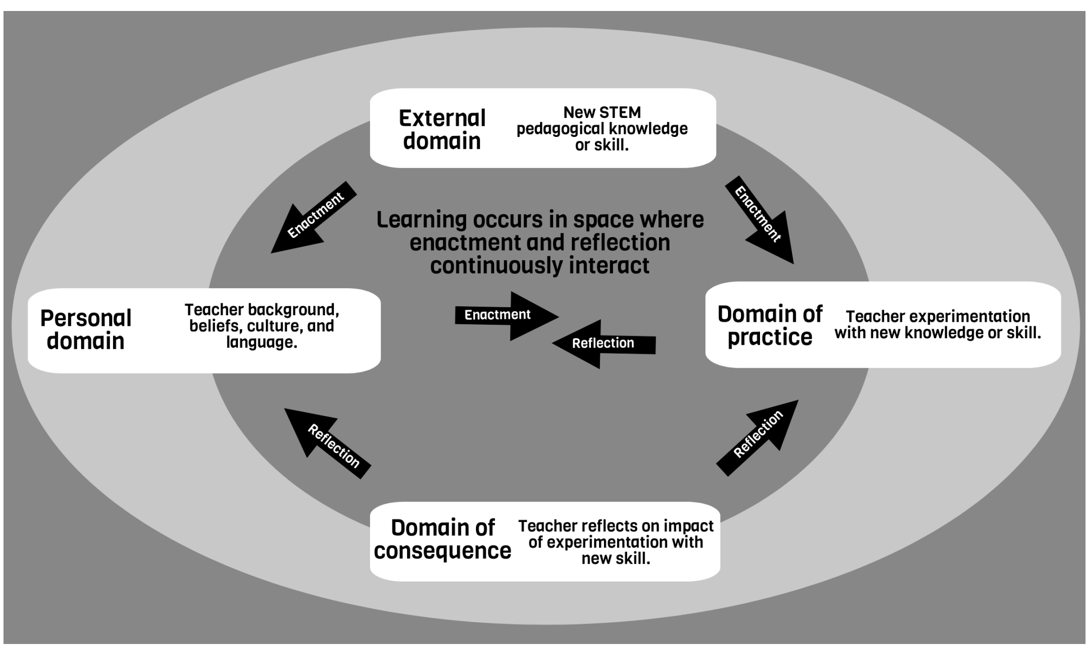
In the context of professional growth, learning occurs in an environment where teachers enact new strategies and reflect on their impact (Clarke & Hollingsworth, 2002). The STEM teacher professional growth model assumes that teacher learning is a nonlinear, continual, and complex process that takes multiple pathways (Perry & Boylan, 2018). Furthermore, teacher professional growth emerges from the interaction between different domains. This interaction leads to, or impedes, teacher professional growth (Justi & van Driel, 2006). The STEM teacher professional growth environment (see Figure 3) illustrates how growth emerges from the enactment and reflection between four domains:

- **External domain:** new information or stimulus
- **Personal domain:** teacher background, beliefs, culture, and language
- **The domain of practice:** opportunity to experiment
- **The domain of consequence:** perceived impact of the new strategy

This interconnected growth model has been used by researchers and practitioners to structure PD programs and understand the process of enactment and reflection (see Coenders & Terlouw, 2015; Wang et al., 2014).

Figure 3

STEM Teacher Professional Growth



Note. Adapted from Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education*, *18*(8), 947–967.

This framework is situated within the constructivist approach since it recognizes the mediating factors of teachers' beliefs and backgrounds. The STEM teacher professional growth environment is centred on the interaction of individual and organizational factors, which is a critical mechanism for organizational change (Bolman & Deal, 2017). This framework can guide the selection of solution strategies that recognize the mediating effects of contextual forces on outcomes (Kafyulilo et al., 2015). Although primarily a descriptive model, it offers guidance to structure PD. When influenced by internal and external change drivers, it will create the desired future state for STEM PD.

Change Drivers

Change drivers are events or behaviours that create the necessity for change or facilitate the change and its adoption (Whelan-Berry & Somerville, 2010). Four change drivers will be discussed. First, as assessed in the PESTEL analysis, the national discourse around education reform has made stakeholders receptive to STEM education. Schulte (2018) outlines how discourse on education at a national level can impact the practices of classroom teachers, even when it runs contrary to school policy. At NCIS, parents have given testimonials on the school's social media about the importance of STEM education, becoming what Ball (2011) calls policy entrepreneurs. When parents convert to policy entrepreneurs, they become powerful change drivers. This advocacy translates to continued community support, investment, and prioritizing of STEM as an institutional goal.

A second change driver is an external one, NCIS's STEM accreditor, Cognia. Cognia sends accreditation teams to assess a school's suitability for STEM certification, for which they use in-field educators from certified STEM schools. Legitimizing the STEM program by certification is of high value to NCIS students and parents (Rojas, 2019), meaning sufficient financial resources have been apportioned to sustain this certification.

The third change driver is in the sphere of teacher education. It is the lack of preservice STEM preparation universities provide for teacher candidates. Shernoff et al. (2017) found a lack of knowledge among STEM teachers and attributed this to a lack of preservice teacher preparation. Similarly, Nadelson et al. (2013) observed that elementary teachers do not receive sufficient preservice instruction in STEM areas, and most do not feel confident with inquiry-based instruction. In a study carried out by Kocabas et al. (2020), only half of middle school math and science teachers hold a degree in their subject area. At NCIS, none of the current elementary STEM teachers hold a degree in a STEM area. This is a change driver since the lack of preservice teacher education on STEM, and lack of certification in STEM areas, mean that schools must shoulder most of the professional learning. This additional driver increases the importance of structured and robust PD on a school level to impart skills and provide common meanings of key STEM concepts.

A final change driver is the evolving meaning and purpose of STEM in education. Carter (2017) argues that STEM education outcomes are human capital development and national competitiveness. Others see STEM as a mechanism to close gender and minority gaps in the STEM workforce (Celepcikay & Tarim, 2015). This illustrates the evolving landscape of STEM and its resistance to a standard definition (Holmlund et al., 2018). STEM education's varied meanings and purposes means any PD program will require sensemaking and clear articulation. The change drivers of national discourse, certification, lack of preservice STEM preparation, and the diversity of STEM meanings will propel change forward; however, mitigating this change is the organization’s readiness.

Organizational Change Readiness

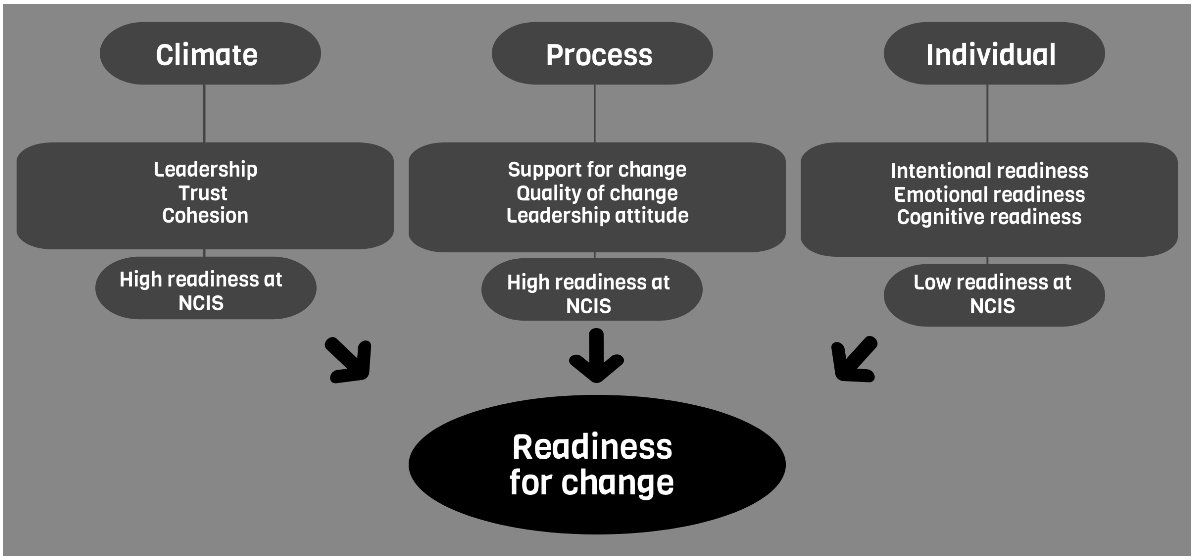
Organizational change readiness determines the extent to which change recipients are prepared to commit to the change effort. Bouckenooghe et al. (2010) provide a tool to analyze change readiness that focuses on organizational and individual levels. This analysis, when applied, suggests that change readiness is uneven, with more readiness in climate and process dimensions and much less in the emotional and cognitive dimensions.

Assessing Change Readiness

A change readiness assessment provides clarity before initiating a complex change process. Change readiness refers to how the organization and individuals involved are collectively motivated and capable of participating in the change (Holt & Vardaman, 2013). When school leadership understands teacher readiness they are better prepared to navigate change (Lynch et al., 2019). Bouckenooghe et al.'s (2010) model identifies climate, process, and individual readiness dimensions and illustrates how these contribute to readiness for change (see Figure 4). In a study on primary teachers and their organizational learning, Miller (2015) found a statistical significance between emotional readiness, cognitive readiness, and organizational learning. Similarly, Rafferty and Minbashian (2019) found that cognitive beliefs and emotional responses to change are critical to success. This model is appropriate to examine readiness at NCIS since it captures the organizational and individual readiness levels seen by research to determine whether change will be successful or not.

Figure 4

Change Readiness



Note: Adapted from Bouckenooghe, D., Devos, G., & Van den Broeck, H. (2009). Organizational change questionnaire–climate of change, processes, and readiness: Development of a new instrument. *The Journal of Psychology, 143*(6), 559-599. https://doi.org/10.1080/00223980903218216

Climate of Change

The internal context is the climate in which the change will occur, including trust in leadership, politicking, and cohesion (Bouckenooghe et al., 2010). For example, a staff survey collected as part of the school's Cognia accreditation showed that 83% of teachers strongly agreed/agreed that leadership made vision-oriented decisions (Cognia School Dashboard, 2021). Another question showed that 87% of teachers strongly agreed/agreed that the administration promoted a collaborative culture. In addition, a Cognia external review team's accreditation report cited a high level of trust and collaboration at NCIS (Cognia, 2019, p. 11). This evidence suggests a climate of trust in leadership and fostering professional collaboration, both indicators of high readiness in the climate dimension.

Process of Change

In the process of change, or when change begins to occur, Bouckenooghe et al. (2010) identify participation, support by supervisors, quality of change, and leadership attitude as critical dimensions. On survey items related to involvement and support, 84% of teachers strongly agreed/agreed that leadership provided opportunities for stakeholders to be involved in the school decisions. In the accreditation report, the external review team scored the school a *Meets Expectation* on the indicator *Leaders engage stakeholders to support the achievement of the institution's purpose and direction*, citing the frequency of surveys, meetings, forums, and social media venues as evidence (Cognia, 2019, p. 4). Thus, there is evidence that processes and structures are in place that support teachers through change and that leaders have demonstrated an engaged approach to change. The indicators for readiness in climate and process for change are high; unfortunately, for this change effort, this pattern does not continue in the intentional, emotional, and cognitive readiness dimensions.

Individual Readiness for Change

Bouckenooghe et al. (2010) describe the third dimension as individual readiness for change that encompasses intentional, emotional, and cognitive states of individuals' disposition for change.

Intentional Readiness. The intentional readiness for change indicates the energy and effort organizational members are prepared to invest in the change process. Time is a limited resource in schools. Due to the pandemic, virtual and hybrid instruction meant teachers had to acquire new skills, materials, and pedagogical strategies, which placed enormous demands on teacher time (González & Bonal, 2021). A survey applied to teachers in May 2021 showed that time management was a significant challenge in teaching while working under pandemic restrictions. Thirty-three percent of teachers selected time management as the number one most challenging aspect of their school day. Principals have also reported that adjusting to in-person school, under restrictions, means that faculty meetings and other spaces typically used for collaboration are now used for logistical items like arrival/dismissal, recess, and cafeteria routines. Staff at NCIS are investing their time and energy in maintaining their students' physical safety and emotional well-being during this transition back to in-person school and have little additional intentional disposition or readiness.

Emotional readiness. The emotional readiness for change is the affective reaction of participants to the change. Before the COVID-19 pandemic, teachers were largely supportive of significant change initiatives. When STEM implementation began, even the most resistant teachers made progress toward implementation goals (Cognia, 2018). However, since the pandemic, when the school moved to virtual learning, then to an alternating hybrid model, then to full in-person learning, change came rapidly and created challenges for teachers. A teacher well-being survey applied in May 2021 showed that 40% of staff reported signs of preclinical anxiety. Turnover of expatriate staff also increased last school year, as international teachers expressed a desire to be closer to their families. Under the current conditions, the emotional dimension's readiness level is low. This is consistent with cognitive readiness which will be discussed in the next paragraph.

Cognitive Readiness. The cognitive readiness for change is the beliefs and thoughts about the advantages and disadvantages of the change. Teachers' dissatisfaction with current STEM PD has been the catalyst for change; even though teachers may see a problem with the status quo, they may be unwilling to invest additional time in the change effort. Therefore, cognitive readiness may be mixed. The impact of COVID-19 is seen in the intentional, emotional, and cognitive readiness of staff.

The evidence presented above would indicate that NCIS has a mixed level of change readiness. Survey data and conclusions from accreditation reports suggest that the internal context dimensions of trust in leadership create an environment conducive to change. Once the change is underway, participation and support may contribute to high change readiness. However, being an educator during the pandemic requires continuous adaptation to virtual, hybrid, and in-person instructional formats. This continual adaptation is affecting teachers' emotional and intentional readiness for change. Leaders will need to manage teachers' emotional and cognitive readiness to promote the change required.

Chapter 1 Conclusion

Chapter 1 introduces the context in which the OIP will occur and examines how these forces shape NCIS's aspirations, organizational structures, and practices. My positionality explains my constructivist approach, which influences my views on education, leadership, and the models adopted for this OIP. The problem being addressed is the lack of adequate and relevant STEM PD, which fails to support teachers as they implement a STEM education at NCIS. Managing this change is challenging due to teacher turnover and dualities at NCIS. An organizational analysis identifies a lack of congruence in the tasks that teachers are expected to carry out and the formal structures that support them, creating a gap in the current and future states. Furthermore, organizational readiness is mixed with a climate that supports change but limited by the burden of being an educator during a pandemic. The context is clear, the forces identified, and readiness assessed. This understanding will provide the foundations for selecting effective approaches and constructing implementation plans.

Chapter 2: Planning and Development

The previous chapter described the context of the problem; this chapter will establish why the change is needed and maps a viable path forward. Theory, context, positionality, and research determine that transformational and distributed leadership approaches should be employed. Selecting a change model is equally important. Three models are compared, and Deszca, Ingols, and Cawsey's change path model, complemented by Duck's change curve elements, is chosen to propel change forward. Next, an organizational congruency model identifies a gap between the task elements, what STEM teachers are expected to do, and the formal structures STEM PD offers. Finally, four solutions are assessed, with a mentoring program being selected as the most impactful solution. This chapter will conclude by using a postcolonial lens to examine Latin American history, international education, and STEM education at NCIS. However, first the leadership model employed will be introduced.

Leadership Approaches to Change

Critical to change is the leadership model. Leadership is a complex endeavour (Sant'Anna et al., 2011) with multiple dimensions and definitions (Northouse, 2019). An approach must be situated within this OIP's theoretical framework, have empirical support, and address the PoP. Two leadership models have been evaluated that, when combined, offer complementary elements that will accelerate the change process.

Transformational Leadership

This approach assumes that leadership is relational, collective, and purposeful. Leaders who practise transformational leadership often profess a personal epistemological belief in constructivism (Tickle et al., 2005). The transformational leader aims to empower followers (Conger, 1999) by fostering capacity development and commitment to goals (Bass & Avolio, 1993). The specific tenets of this model are the four I's of transformational leadership:

intellectual stimulation, individual consideration, inspirational motivation, and idealized influence (Bass & Avolio, 2006). These empirically informed behaviours will be key leverages for the solution strategies outlined in this section.

Literature on Transformational Leadership

Transformational leadership has substantial empirical support. It has demonstrated effectiveness in motivating teachers to achieve goals and improve climate (Allen, 2015). When individuals develop a shared vision, they take pride in their work (Harris & Kemp-Graham, 2017) and innovation increases (Mittal & Dhar, 2015). Teachers who believe that their leaders demonstrate transformational leadership behaviours identify more with the leader and are more optimistic about the school climate (Allen et al., 2015). Day et al. (2016) found that effective and improved schools in England had principals who exhibited transformational leadership behaviours, such as building staff capacity, providing a range of learning opportunities for teachers, and articulating a clear vision. The empirical evidence suggests that this leadership approach will propel change forward.

How Transformational Leadership Propels Change Forward

Transformational leadership offers ways to accelerate change. First, this approach emphasizes a supportive environment that encourages STEM teachers' participation in program design and professional growth (Bass & Riggio, 2005). Second, as teachers experiment with new strategies and reflection, transformational leadership will help them see the interdependence of their learning and their colleagues, increasing collective responsibility (Beverborg et al., 2020). Third, the cultural competency of the change leader will make transformational leadership more potent, especially when considering teachers' emotions, which are critical in change initiatives (Lawson et al., 2017).

Equally important to propelling change forward is engaging stakeholders resistant to change. Transformational leaders are dedicated to setting a vision, raising followers' consciousness about purpose (Drysdale et al., 2016; Shields, 2012), and encouraging followers to transcend their individual needs (Beverborg et al., 2020). For example, since the gap exists between the tasks that teachers are expected to carry out and the PD structures in place, an emphasis on the benefits of learning collectively, through mentoring, will help motivate unengaged or resistant stakeholders (Holt & Vardaman, 2013). Finally, personal consideration for followers' emotions, a transformational leadership behaviour (Northouse, 2019), will be critical as teachers face the discomfort of enacting new instructional strategies. Despite benefits, there are criticisms of this approach.

Critique of Transformational Leadership

Some literature has uncovered inconsistencies in the effectiveness of transformational leadership. For example, one study found that male teachers reported less intrinsic motivation than female teachers when their principals exhibited transformational leadership practices (Serin & Akkaya, 2020). Another critique is that transformational leadership may lack a clear conceptual definition and empirical distinctiveness, creating overlap with elements of other leadership styles (Berkovich, 2016). Finally, Shields (2012) recognizes the approach's strengths for setting the direction, developing people, and redesigning the organization but questions *what* direction, *how* to develop people, and what redesign *means*. Despite these critiques, there is sufficient evidence for this approach's effectiveness and when complemented by distributed leadership, can provide a more robust leadership framework to affect change.

Distributed Leadership Approach

Distributed leadership offers a secondary but still important leadership approach for this OIP. Distributed leadership assumes that an over-fixation with the leader is problematic and so this approach centres on how power relations influence followers' motivation, practices, and knowledge (Spillane, 2006). Leadership is stretched over multiple individuals in holding formal or informal leadership positions (Thien, 2019) and is a collaborative, interactive, and participative approach where leadership is not fixed but fluid and emergent (Harris, 2008). Those exercising this leadership approach interact with each other to create artifacts, situations, and meanings specific to the organizational context. This situates distributed leadership in a constructivist paradigm (Nerlino, 2020).

Even though there may be similarities between transformational and distributed leadership, such as focusing on vision building and empowerment, differences make these approaches complementary. One difference is that distributed leadership's focus extends beyond the leader to examine the practices of many individuals engaged in leadership. This means distributed leadership focuses on the *how* of change and the *what*, addressing some transformational leadership criticism (see Shields, 2012). Additionally, as discussed in the next paragraph, distributed leadership has empirical support.

Literature on Distributed Leadership

Although a continually evolving field of research, distributed leadership has empirical support demonstrating its potential for organizational change (Harris et al., 2007). In schools, distributed leadership is correlated with increased teacher efficacy (Rashid & Latif, 2021). Both Dan and Gary (2018) and Kilpatrick and Fraser (2019) illustrate how teacher mentoring leverages teachers' previous experience and expertise to build collective STEM instructional capacity. In addition, distributed leadership multiplies those in leadership roles, deepening understanding of the social structures in the changing environment (Schulte, 2018). Since the change at NCIS intends to increase stakeholder participation and address readiness, leaders will need to understand the micropolitics of the organization (Fasso et al., 2016). This approach offers a way to build collective capacity, multiply leadership roles, and address readiness. For these reasons it offers an effective way to accelerate change.

How Distributed Leadership Propels Change Forward

Distributed leadership complements transformational leadership; it is also coherent with the context and nature of the OIP. For example, NCIS's STEM program is led by two coordinators who oversee curricular implementation, planning, and teacher development. This distribution by design model, typified by creating formally designated leadership positions that enable the distribution of responsibility, offers an effective leadership model for schools engaging in reform efforts (Spillane, 2006). Distributed leadership may also lessen teacher turnover. Both Mancuso et al. (2010) and Desroches (2015) found that a willingness to share decision-making and distributed leadership reduced teacher turnover in international schools— a line of inquiry of this OIP. In addition to lowering turnover, this approach also addresses disengaged or resistant stakeholders.

Distributed leadership's focus on multiplying leadership roles empowers more stakeholders. This has two effects. First, more individuals participate in building the vision for change, and therefore understand it better (Harris, 2008). Second, multiple leaders deepen the collective understanding of the landscape and micropolitics of where the change will take place (Fasso et al., 2016). Both these characteristics of distributed leadership decrease resistance of stakeholders to the change effort. Even so, like transformational leadership, this approach is not free from criticism.

Critique of Distributed Leadership

Some critics question whether distributed leadership's dependence on informal influence can coexist with the hierarchical structure predominant in most schools (Harris, 2008). For example, Fasso et al. (2016) assert that the distributed leadership framework overfocuses on the elements of the model, ignoring the social distribution of leadership and the nature of the task enactment. Similarly, Lumby (2013) questions the assumption of power, suggesting that barriers like gender or race constrain individuals' influence as a leader, even when leadership is formally designated to them. Acknowledging this criticism means that distributed leadership, as with transformational leadership, must be employed with a firm understanding of the organization's context, change readiness, and leadership ethics.

Transformational and distributed leadership, when combined, offer powerful models to propel change forward. Transformational leadership's focus on learning and distributed leadership's focus on shared responsibility align these two approaches with the change vision of this OIP. The literature indicates that when leaders focus on vision building, empowering teachers, and distributing leadership, climate, motivation, and goal achievement improve. The following section discusses how aligning the leadership approach and the selected change model will optimize the change effort.

Framework for Leading the Change Process

Change is complex and sometimes unpredictable, so applying theory is vital to maintain coherence and effectiveness in the change effort (Smith & Graetz, 2011). Change models allow leaders to integrate competing visions, face ambiguities, and address assumptions underlying change (Capper & Green, 2013). The type of change, revolutionary or evolutionary, is also a critical consideration for selecting a change framework. Two additional considerations are important for this OIP, the framework's emphasis on organizational learning and alignment with the chosen leadership approaches. Two models emerge from this analysis— Deszca, Ingols, and Cawsey's change path model and Duck's change curve. These models suit the contextual elements of this OIP and will provide a path to enact change. Before discussing the two change models, it is important to understand what type of change is taking place.

Type of Change

Change can be revolutionary or evolutionary (Burke, 2017). Revolutionary change requires a new mission, culture, leadership, and strategy. Evolutionary change requires a partial change to an organization, improvements, or incremental steps. However, when viewing the change needed at NCIS through psychological, organizational, scientific, biological, and mathematical frames, it becomes apparent that it is evolutionary (see Table 1). The catalyst for the change is teacher dissatisfaction with current practice, which suggests the change will not alter the broad strategic vision of STEM education at NCIS. Furthermore, the change is an evolution of practices to address the identified gaps, as determined by needs, context, and extant research.

Table 1

Revolutionary Versus Evolutionary Change

Domain	Revolutionary	Evolutionary	OIP Change Process
Psychology	Individuals make dramatic, rapid life-altering changes	Individuals live life through a relatively orderly sequence	The outcome will not change the identity or vision of the STEM program or school
Organizational	Change that requires new patterns of operation.	Change addresses problems, strategic orientation remains	To address the gap in STEM PD, school vision unaltered
Science	Paradigmatic shift	Knowledge incrementally accrued to support the theory	A paradigmatic shift in approach to STEM teacher professional growth
Biology	Punctuated equilibrium	Variation and adaptation	Change to STEM PD adapting to context, needs, and research
Mathematics	5% of change	95% of change	Most likely, occurs in the 95% of organizational change

Note. Grey shading indicates the most accurate description of the type of change needed. Adapted from Burke, W. (2017). *Organizational change: Theory and practice* (5th ed.). Sage Publications.

Change Path Model

This section will assess a suitable change models. For this OIP, two change models are evaluated for suitability for evolutionary change, including whether they address learning and align with the leadership approach. The change path model assumes that change is complex but predictable and can be managed with discipline and planning (Deszca et al., 2020). This model offers advantages over other change models (see Appendix D). First, the change path model emphasizes learning, focusing on past experiences to adapt approaches and build new knowledge (Deszca et al., 2020). For instance, at NCIS, teacher experiences with different instructional strategies can be adapted to meet needs in STEM instruction. Building teacher capacity is central to both the objectives of this OIP and aligned with transformational leadership approaches (Bass & Avolio, 1993). Equally important is communicating the change vision.

Another major emphasis in the change path model is constructing and communicating a vision for change and inspiring followers (Deszca, 2020). Creating a vision for change and inspiring followers are major tenets of transformational leadership. Furthermore, NCIS has a communications office, which can ensure that the vision for change, once constructed, can be tailored to different audiences and communicated throughout the change effort.

The change path model scans the environment and assesses the external and internal foundational forces that will allow change to happen during the awakening stage. Finally, this model focuses on the interaction of the individual and the group, which is central to communities of practices and mentoring solutions strategies. Therefore, the change path model is selected for this OIP and, when complemented by Duck's change curve, offers a powerful pathway to needed change.

Duck's Change Curve

The change path model focuses on individual learners adapting to new ways and behaviours; however, a second model specifically addresses emotions as change happens. Duck's (2001) change curve assumes that emotions accompany all types of organizational changes. When confronted with change, individuals' emotional reactions follow predictable stages. Duck's model acknowledges that individuals' emotions are potent influences on their reality and acceptance of the change. Furthermore, this model aligns with the theoretical approach to the OIP since, from a constructivist perspective, context and previous experiences mediate people's conception of reality and emotional reactions (Kritt, 2018). The re-orientation of the STEM PD to promote more teacher participation acknowledges that teacher experience, background, and beliefs are critical elements of professional growth.

Duck describes five stages of the change curve. The first is stagnation, when there is little feeling of variance from the status quo. The second is preparation, when internal or external forces precipitate change and the immediate emotional reactions. Then follows implementation, where new structures and plans change people's mindsets and habits. The next phase is determination and the realization that change is real and will need new skills to be developed. Finally, the last phase is fruition, where the changing structures or skills have salient results. The compatibility of these stages of the change curve with the change path model means that they can be integrated (see Appendix E).

Awakening–Stagnation

The change path model and the change curve can be integrated into four steps as illustrated in Figure 5, starting with the awakening-stagnation phase. The awakening–stagnation phase can be described as confirming the problem, articulating a performance gap, and developing and communicating a change vision (Deszca et al., 2020). This phase requires understanding the external and internal drivers shaping the organization's context (i.e., STEM national discourse, accreditation, lack of preservice learning, and turnover). However, knowing these factors is not enough; the change leader must articulate the performance gap and change vision. This can be done by encouraging key stakeholders to notice features of their environment, interpret what is going on, and seek to initiate change (Lewis, 2019). This means that change leaders at NCIS must take data from teacher surveys and highlight external and internal change drivers to create an appetite for change to move organizations out of stagnation (Duck, 2001).

Figure 5

Change Path Model

Note. Adapted from Deszca, G., Ingols, C., & Cawsey, T. F. (2020). *Organizational change: An action-oriented toolkit* (4th ed.). Sage Publications.

Mobilization–Preparation

The core activities in the mobilization–preparation stage are building support, assessing formal structures, broadening communication of the vision for change, and constructing an implementation plan. To build support, leaders need a clear understanding of stakeholder groups. Using Ball's (2011) typology of roles, NCIS stakeholders' roles, needs, and values can be evaluated (see Table 2). This insight will allow change leaders to address stakeholder anxiety and convert it to anticipation (Duck, 2001). The final core activity in this stage is to construct an implementation plan that outlines key actors, timelines, resources needed, the skills required, measurement, outcomes, and oversight. Finally, a communication strategy will need to present a compelling vision of change to the stakeholders, nurturing their energy and demonstrating how it will create value for the recipients (Duck, 2001).

Acceleration–Implementation

During the acceleration–implementation phase, change leaders will be engaged in empowering and deploying change teams, constructing a communication plan, executing implementation plans, managing transition, and celebrating key milestones. As the complexity of the change effort increases in this stage as more participants are involved and the implementation is taking hold, the sharing of leadership becomes critical (Harris et al., 2007). Duck calls this broadening the involvement and creating allies to reach the rest of the organization. Since coordinators are frequently working with STEM teachers in the classroom, they better understand the challenges that teachers face daily. Assigning leadership responsibilities to STEM coordinators will leverage their knowledge of situational factors to inform implementation (Schulte, 2018) and distribute leadership.

Communication at this phase focuses on current status, next steps, and celebrating key milestones (Deszca, 2020; Duck, 2001). Existing communication channels at NCIS, such as social media, parent open houses, faculty meetings, and open forums, allow communication to target different stakeholder groups (Armenakis & Harris, 2001). Duck suggests building behaviour first by concentrating on a single issue that could show tangible results and make a difference to sustain energy and enthusiasm as change becomes more complex.

Institutionalization–Determination–Fruition

Essential work during the institutionalization–determination–fruition phase is monitoring, organizational restructuring, and preparing for future changes. Deploying metrics creates benefits such as clearly defined outcomes, allocating resources, monitoring progress, making corrections, and managing risk (Deszca, 2020). In addition, employing a strategy map makes the change plan more transparent and provides a clearer understanding of actions and intended results (Strategic Direction, 2021).

As institutionalization changes the previous habits and reality of the organization, making people change their behaviour may create "retroactive resistance," a phenomenon where individuals lose enthusiasm after initially supporting the change initiative (Duck, 2001, p. 198). The STEM PD policy will require scheduling changes, a shift in how PD budgets are executed, and a move away from external PD to focus on more contextual and continuous teacher learning. Celebrating and recognizing those involved in the change efforts is essential to prepare the organization for future work.

Before the final selection of the change model, a third model was assessed (see Appendix D). Lewin's stage theory of change suggests that change goes through three phases: unfreeze, change, and refreeze (Hussain et al., 2018). According to this model, the unfreezing results from a crisis (Northouse, 2019) and does not account for change being evolutionary or revolutionary. Furthermore, learning is not explicitly addressed in Lewin's model. Since building teacher capacity is a central pillar of this OIP, the lack of consideration for learning in this change model is a drawback. These reasons preclude this change model from being used with this OIP.

Change is complex and requires a firm theoretical grounding. The change path model and Duck's change curve offer two approaches for leading the change process that complement each other. Both models focus on the teacher learning that needs to occur, embrace the complex nature of change, and address the emotions of change participants through clear communication, stakeholder consideration, and vision building. Additionally, both models incorporate behaviours essential to transformational leadership and distributed leadership. Finally, both offer a lens to assess the needed change in the organization, which is the focus of the next section.

Critical Organizational Analysis

The critical organizational analysis will use four lenses to assess needed organizational change: organizational congruence, change readiness, the dualities framework, and a postcolonial lens. This analysis suggests that there may be incongruence in the task and people elements of the organization. A change readiness analysis exposes a need for a better articulation of the STEM PD vision and outcomes so that teachers understand what is expected of them. An assessment of stakeholder values determines that groups differ with respect to STEM, with teachers desiring PD that more effectively addresses the pedagogical skills needed. Finally, a postcolonial lens illustrates how STEM PD practices entangle NCIS in a colonial legacy. Before applying these lenses, it is essential to note the current state of STEM PD at NCIS.

The description of the NCIS STEM PD program, submitted for certification in 2018, reports it as a workshop-based approach coordinated by the STEM coordinators and establishes three school PD days for STEM PD (NCIS, 2018). A STEM PD budget funds teachers' participation in STEM PD courses and supports PD events on the school campus. STEM coordinators collect PD evaluation and teacher survey data to inform the PD days plan and work with section principals and the director on the logistics for the day. Despite this structure, a gap between teacher needs and support remains, which is illustrated by an organizational congruence lens.

Organizational Congruence Lens

Nadler and Tushman's organizational congruence model assesses the fit between elements of culture, structures, tasks, and people. In chapter 1 this model was used to identify priorities for change. In this section, this model will be used to further diagnose and analyze the needed change. Congruence between elements contributes to achieving organizational outcomes, but a lack of congruence will impede it. In the case of NCIS, the task of teachers is to implement STEM and provide students with inquiry-based, integrated instruction. This task requires pedagogical knowledge of planning, developing, teaching, and assessing high-quality, interdisciplinary units that address learning standards from different STEM areas (Duschyl & Bybee, 2014).

The data suggest that there is a gap in this area. Classroom observation data that assess active learning and digital integration show that scores have not changed pre– and post–STEM implementation (see Appendix A). Furthermore, a survey of NCIS teachers showed that 71% desired more STEM PD, suggesting that teachers do not feel sufficiently prepared to implement the STEM program (see Appendix B). This is evidence that NCIS is not carrying out the tasks necessary to achieve the stated outcomes of STEM implementation.

With a shortfall in the task component established, the attention can shift to the organization's formal structures. At NCIS, the formal structure of STEM PD lacks an articulated policy and long-term planning. In absence of a coherent vision, a workshop-based model has been adopted. This approach is problematic for two reasons. First, the PD days are planned independently, without forethought on creating a continuity of learning, known to contribute to teacher growth and confidence (Nesmith & Cooper, 2019). Second, this one-off workshop model also lacks a theoretical framework, which prevents the coherence needed to support sustainable teacher growth (Bush et al., 2020). While there is nothing inherently wrong with one-off workshops, they do not provide the recurring cycles through which enactment and reflection contribute to teacher growth (Witterholt et al., 2012). The lack of a comprehensive and coherent STEM PD means that NCIS's formal structures are not supporting the tasks that contribute to organizational outcomes. This creates a lack of congruence between the tasks and formal structures. When looking to address this gap, the readiness of the organization must also be considered.

Change Readiness Lens

Another way to determine what needs to change at NCIS is by applying change readiness as a lens to identify needed changes. Change readiness refers to the extent the organization and individuals involved are motivated and capable of change (Holt & Vardaman, 2013). As discussed in Chapter 1, there is a high readiness in the climate of change and cognitive readiness on the individual level (Bouckenooghe et al., 2010). However, intentional readiness, as defined by the willingness of organizational members to devote energy and effort to the change process, is low. Emotional readiness, the affective reaction of participants to change, their feelings about the change project, and their disposition to change is similarly low.

Low change readiness is a problem since successful change requires the interdependence of individuals and is contingent on collective attitudes (Holt & Vardaman, 2013). As mentioned above, without an articulated STEM PD policy at NCIS, it is difficult to create a consistent vision with clear expectations and outcomes (Arafeh, 2014). Avolio and Hannah (2008) illustrate how unclear expectations and lack of participation from key individuals hurt readiness and hinder change. When readiness is uneven across the intentional and emotional dimensions, leaders must focus on the people's beliefs, attitudes, and dispositions to the change.

Addressing Readiness

Fortunately, leaders prepared to construct and communicate a clear change vision may increase readiness. Rafferty et al. (2013) stress the importance of a transformational leadership approach that conveys a clear and inspirational vision and creates positive responses to change. Developing awareness of what followers should expect and how changes will affect people can lead to positive attitudes toward the change (Napier et al., 2017). In the context of this OIP, adhering to the change path, specifically communicating the change vision and implementation plan, both part of the awakening phase and mobilization phase, respectively, will increase readiness. Furthermore, the final activities in the mobilization phase involve providing the skills needed to enact the change, seen to increase acceptance (Holt & Vardaman, 2013). Despite the low readiness, concrete actions can promote positive attitudes and commitment to change.

Change Path Model Lens

In addition to congruency and readiness factors, the change path model provides another lens to assess the organization. In the mobilization stage a stakeholder assessment should be carried out. At NCIS, a market survey was commissioned in 2019, using surveys, focus groups, and interviews with all stakeholder groups to assess their perceptions of the school, including areas of strength and improvement (Rojas, 2019). Based on this report, Table 2 outlines stakeholder values, their role in policy change according to Ball's (2011) typology, and whether they value pragmatic or idealistic outcomes.

Table 2

NCIS Stakeholders' Values and Policy Roles

Stakeholders	Values	Keller's Duality	Role in Change (Ball, 2011)	Consideration for Solution Strategy
Teachers	Innovative approach, professional capacity building	Idealistic	Receivers	Engaging these stakeholders in interpretation better aligns with policy enactment (Fasso et al., 2016; Honig, 2002)
Coordinators and principals	Value resources, STEM program and school strategic goal alignment	Idealistic	Narrators: interpretation, meaning-making	Alignment of organizational goals and STEM program goals, additional time and resources
Board of directors	Value STEM certification as a differentiator over competitor schools and an added value for current families	Pragmatic	Transactors	STEM education can be framed as value-added
Cognia	Value growth of several schools with STEM certification	Pragmatic	Outsiders	Certification provides a pathway and the legitimization of the program.
School parents	Value STEM as an innovative and progressive approach to education; value STEM certification for value added to diploma	Idealistic and pragmatic	Receivers	Parents value concrete, pragmatic outcomes (Kurt & Benzar, 2020; MacKenzie et al., 2001; Weenink, 2008)
Students	Value STEM as an innovative approach to education, value; STEM for value added to diploma	Idealistic and pragmatic	Receivers	Students benefit from better instruction and continued STEM program certification

According to this report, stakeholders value STEM for different reasons, with teachers and coordinators valuing it for its innovative approach and alignment with the school vision, respectively (Rojas, 2019). In addition, teachers value the challenges of teaching STEM and recognize the potential for professional growth. When considering this information with the gap previously identified by the organizational congruency assessment, it becomes apparent that teachers are eager to teach STEM. Still, they see the potential for better PD. STEM coordinators, another key stakeholder in this change effort, value the broader outcomes of STEM. They are the ones who carry out the current PD program and would welcome the increased resources, time, and agency that prioritizing this area would bring. When stakeholder values are considered alongside congruency and readiness factors, the needed change comes into focus. Applying a postcolonial lens to the current state of STEM PD will complete this analysis.

Postcolonial Theory Lens

Postcolonial theory offers an additional lens to evaluate needed change at NCIS. At NCIS, the STEM program is certified by Cognia, which uses an accreditation framework based on a U.S. conception of STEM education (Cognia, n.d.). Furthermore, NCIS has partnered with a project-based school system in California to provide STEM PD. Applying a postcolonial lens to examine these practices offers opportunities to expose forms of meanings, understandings, and expressions of postcolonialism (Lavia, 2007). Often school leaders do not recognize the colonial legacy or are not able to influence the patterns currently in place (Nguyen et al., 2009). Using this lens to diagnose the condition for change can provide a pathway away from overdependence on U.S. educational practices.

The overrepresentation of U.S. educational practices in international schools is well documented (see Villegas-Reimers, 2003). A more elaborate discussion of postcolonialism and its impact on education in Latin America appears at the end of this chapter. Suffice to say postcolonial influences on STEM PD means privileging Western-centric epistemologies, which risks the disengagement from STEM education by teachers and students from different backgrounds (Rahm, 2014). One practice in question is the language of the majority of U.S.-source STEM PD.

Many U.S. sources and providers of STEM PD are in English only, creating barriers to many staff members. Although most NCIS staff are bilingual (English–Spanish), this still leaves approximately 28% of teachers who are Spanish-only and cannot fully participate in English-only PD. A paucity of multicultural approaches and the lack of Spanish STEM PD risks delegitimizing teachers' historical and cultural repertoires (Gutiérrez et al., 2011), removing agency from teachers and impeding professional growth (Briceño et al., 2018).

The language of U.S. sources of STEM PD and the privileging of Western-centric ways of seeing and knowing the world are both remnants of colonial influences on education. A new approach to PD that does not separate languages but offers multilingual spaces will optimize learners' prior knowledge base and cultural background. Furthermore, this change will represent a shift away from pragmatic practices to a more equitable and pluralistic approach aligned to a global civil society vision.

The organizational congruence, readiness, and change models provide a different lens to assess needed change. Taken together, these lenses have identified four areas for change. First, STEM instruction requires content knowledge and pedagogical skills, yet the current PD is not supporting teacher growth in these areas. Second, there is a lack of clarity around STEM vision, expectations, and outcomes, which are not clearly communicated. Third, stakeholder values differ depending on their role in the school, but they coincide in beliefs about STEM PD. Finally, the adherence to U.S.-based PD models, as encouraged by the accreditation agency, promotes postcolonial patterns and contributes to inequity at NCIS and the exclusive use of English as the medium of PD. This evaluation informs the solution strategies that will address the PoP, which will need to address the gaps, acknowledge the challenges, and create the change that addresses equitable teacher learning and growth.

Solutions to Address the Problem of Practice

As discussed in the critical organization analysis, several gaps require attention. First, there is incongruence between what tasks teachers are expected to carry out and the PD structures in place. Second, there is a lack of STEM PD vision and expectations. Finally, postcolonial practices evidence an equity gap. This requires the school to articulate a STEM PD vision that addresses the pedagogical skills needed to plan, teach, and assess STEM classes and clarify expectations and outcomes. Finally, the solution must shift from the sole dependence on U.S.-source STEM PD. Ultimately, these solutions will address the uneven change readiness of the educators in the organization and the postcolonial patterns that persist at NCIS.

Four solutions will be evaluated: policy articulation, mentoring program, communities of practice, and continuing with the status quo (see Table 3). The benefits, resources needed, trade-offs, and relation to the leadership approach of each of the solutions will be discussed (see Table 3). The results of this assessment point to a mentoring program as the solution with the most potential to affect change at NCIS.

Table 3

Solution Strategies

Solution	Benefits	Impact	Trade-offs
Policy Articulation	Creates vision and clarity	Addresses lack of articulated outcomes	Policy envisioning is not enactment
Mentoring	Builds relationship trust and collective responsibility for learning	Addresses lack of relevancy	Teacher turnover may impact continuity of program
Community of Practice	Promotes reflective practices	Shifts from workshop based to interconnected model of growth	Structure is resistant to outcome-driven planning.
Status Quo	Meets STEM certification standards	None	Does not address the postcolonial patterns embedded in current practice.

Solution Strategy #1: Articulating a STEM PD Policy

The first solution is constructing a policy that articulates the purpose, principles, methodology, and outcomes of a STEM PD program. The current articulation of the STEM PD is a brief paragraph suggesting a workshop-based method and naming the STEM coordinators as facilitators of this program. However, this document is missing a theoretical framework, clear outcomes, a methodology, and targeted content knowledge and skills—all tenets of effective STEM PD (Avery & Reeve, 2013; Guskey, 2003; Yoon et al., 2007).

Resources

This policy work will require investment in time and human resources. Fortunately, NCIS has two STEM coordinators familiar with extant STEM research, program design, accreditation frameworks, and internal data, so no additional staff or PD is needed. In addition, since the school's board of directors highly values STEM program certification, adequate financial resources and technology investments are sufficient to support this strategy.

Benefits

An articulated policy will create a vision, clarify participant expectations, and establish a philosophical foundation. This way, STEM PD can be planned with the end in mind, allowing for better organizational support and identifying desired educator knowledge and skills (Guskey, 2014), thus addressing incongruence. Furthermore, engaging STEM coordinators and teachers in elaborating policy provides interpretation, meaning-making, and shared decision-making known to improve policy enactment (Honig, 2006). Finally, policy development may address postcolonial practices by addressing the lack of access to STEM PD in Spanish.

Trade-offs

There are two trade-offs in pursuing this strategy. The first is that policy envisioning does not always equal enactment in schools, especially when implementers are not involved in the policy creation (Schulte, 2018). Although important in this OIP, policy construction may be insufficient to change people's minds and behaviours needed for change (Duck, 2001). Second, formalizing policy may remove judgement and freedom currently enjoyed by specific individuals at NCIS and may upset some groups' power and influence (Honig, 2006).

Relation to Leadership Approaches

Constructing policy aligns with the transformational leadership approach employed in this OIP since policy facilitates articulating a clear vision. Policy construction allows leaders to be involved in the discursive articulation of that policy to create an institutional narrative and compelling vision for the school (Ball, 2011). Furthermore, the policy will allow for the deliberate arrangement of formal and informal leadership roles, such as division of labour, co-performance, or parallel performance, thus allowing leadership to be distributed across the organization (Spillane, 2006).

Solution Strategy #2: Mentoring

The second solution is implementing a mentoring program, where experienced STEM teachers support teachers new to the school or STEM instruction. The mentoring focuses on building collective capacity through the development of pedagogical skills needed to plan, assess, and deliver inquiry-based STEM instruction. The program will include semistructured interactions and spaces for participants to engage in empirically supported activities such as collaborative goal setting, reflective conversations, and co-inquiry into problems of practice (Mincu, 2015; Richmond et al., 2017).

Resources

Although some limited informal mentoring is occurring at NCIS, a structured program with the scope envisioned in this OIP will require an investment in resources. Fortunately, the involvement of a mentor is the most powerful and cost-effective intervention in an induction program (Glassford & Salinitri, 2008). The responsibility for this program will be assigned to a coordinator, principal, or lead teacher. Mentor teachers may also receive a stipend for their additional work. Although most mentoring programs are site-based, an investment in acquiring and training in videoconferencing technology may permit mentoring and mentees to connect virtually, generating equally impactful experiences over long distances (Kilpatrick & Fraser, 2019).

Benefits

The benefits of a mentoring program include increasing relational trust, addressing the lack of pedagogical skills, empowering teachers, and promoting enactment and reflection as a model of professional growth. Relational trust between mentor and mentee can be enabled by the program's focus on shared experiences, a culture of openness, discussion groups, and celebrations (Aspfors & Fransson, 2015). The research suggests that mentoring programs for new STEM teachers increase the relevancy of PD through co-inquiry into problems of practice, building collective capacity (Martin et al., 2020), and addressing the challenges that teachers face daily in the classroom (Dan & Gary, 2018).

The mentoring strategy offers ways to address stakeholders reluctant to change. Since many new teachers find themselves teaching STEM areas they are not qualified for (Kocobas et al., 2020), relevant and timely PD will increase their confidence (Nesmith & Cooper, 2019). When organizational members are provided with the skills needed to perform new tasks, acceptance of change increases (Holt & Vardaman, 2013). Furthermore, mentoring will allow teachers' backgrounds, cultures, and experiences to mediate their learning, increasing relevancy. When teachers are provided the skills they need to face change and see their backgrounds and cultures represented in the change, readiness will increase.

Mentor interactions may take place in English, Spanish, or both. The planned use of different languages for input and output is called pedagogical translanguaging (Cenoz & Gorter, 2021). It is a theoretical and instructional approach that does not separate languages but offers multilingual spaces that optimize learners' prior knowledge base and cultural background. For example, the STEM PD resources may be available in English, but they may be discussed in Spanish, with English words mixed in. Pedagogical translanguaging is learner-centred, transcends language to influence knowledge acquisition (Garcia & Kleyn, 2016), and offers a solution that shifts away from postcolonial practices to ones coherent with a global civil society vision.

Trade-offs

New mentors will need to be added each year. The expatriate staff turnover rate at NCIS averages between 27% and 38%, and if those teachers are mentors, then turnover will require the continual recruitment and development of new mentors. In addition, finding experienced STEM teachers who fit the criteria, have the time, and are willing to commit to a mentoring program will be challenging. Another challenge is mentee resistance; for example, Schulleri and Saleh's (2020) study of a mentor program in an international school found that resistance emerged when there was a lack of clarity of program activities. Finally, although many mentoring programs run the course of one school year (Richmond et al., 2017), the learning associated with effective mentorship takes multiple years to develop (Aspfors & Fransson, 2015). This lag means that the impact of this program may not be seen for some time.

Relation to Leadership Approaches

This solution strategy aligns with behaviours associated with transformational and distributed leadership. A mentoring program that promotes collaborative goal setting co-inquiry, and collective responsibility of PD aligns with distributed leadership practices (Kilpatrick &

Fraser, 2019). This shared decision-making is seen to increase teacher retention in international school settings (Mancuso et al., 2010). Moreover, mentoring supports teacher learning, well-being (Aspfors & Fransson, 2015), and shared inquiry (Hargreaves & Fullan, 2000) and thus aligns with a transformational leadership approach.

Solution Strategy #3: Communities of Practice

A third solution strategy is the implementation of communities of practice (CoPs) for STEM instruction. Drawing on collective learning and expertise, communities of practice are when teachers have a shared passion for a topic and regularly come together to share and learn (Wenger, 2009). Characteristics of CoPs include a shared interest, a community with norms, and the continual process of sharing experiences. The objectives of STEM CoPs at NCIS will be to create a shared vision for STEM education, engage teachers in reflective dialogue on STEM instructional practices, and foster collective responsibility for professional growth.

Benefits

The benefits of CoPs are the proliferation of best practices in STEM instruction, building the collective instructional capacity of teachers, and focusing on reflection. Implementation of CoPs increases the sharing of experiences, insights, and meaning-making across the organization (Agarwal & Agarwal, 2016). STEM teachers involved in the CoP, whether they were experienced or novices, report an increase in peer learning, collegial planning, and effective use of resources (Kilpatrick & Fraser, 2019). Like mentoring, the CoPs promote reflective practices, which support the enactment and reflection crucial to professional growth from a constructivist perspective.

Resources

The participation of teachers in the CoPs requires the investment of time and consistency to generate learning (Pyrko et al., 2017). Typically, CoPs have an individual facilitating the group, who will need to be developed and perhaps compensated. As CoPs are increasingly organized online, technology platforms for videoconferences and other collaborative platforms for work-sharing and presentation will need to be provided and leveraged to include professionals in different geographical locations (Lejealle et al., 2021). Overall financial costs would be comparable to the mentoring solution.

Trade-offs

The trade-off with this solution strategy is the loose nature of the CoPs. To ensure that the learning emerges naturally, organizations implementing CoPs should encourage them but not overly administer them (Agarwal & Agarwal, 2016). However, this creates a dilemma since one of the assumptions of this OIP is that PD efforts need to be planned, purposeful, and outcome-driven (Guskey, 2003; Yoon et al., 2007). Therefore, for CoPs to be a successful strategy in this OIP, a careful balance between loose encouragement and tighter structuring needs to be struck to promote authentic learning.

Relations to Leadership Approaches

There is alignment with this solution strategy to the leadership approaches. Communities of practice are social structures to help people learn (Wenger, 2009). This aligns with transformational leadership's focus on forming communities committed to teacher growth (Jacobsen et al., 2002). In addition, effective CoPs require leadership to encourage collaboration and ensure free interaction between various hierarchy levels (Pyrko et al., 2017). This is one of the structures that Spillane (2006) refers to as supporting leadership distribution.

Solution Strategy #4: Status Quo

The status quo deserves to be evaluated alongside the other strategies since it draws resources, aligns with some leadership approaches, and contains foundational assumptions. For example, the STEM PD program is currently a workshop-based model that attempts to address teachers' needs during PD days. Workshops on developing integrated projects, using technology tools to increase digital learning environments, and creating rubrics that assess inquiry-based learning are just some of the recent areas of focus.

Benefits

The benefit of the current STEM PD program is that it meets standards for STEM program certification. In addition, there is a structure to evaluate each PD activity through exit tickets and surveys, allowing workshops to be improved continuously. Finally, recent PD activities have enlisted teacher presenters to provide broader offerings, allowing for more relevant topics, distributing the leadership, and generating collective capacity-building responsibility.

Resources

The PD program is coordinated by the STEM coordinators and the section principals. It requires an investment in time and planning. The school calendar includes a week of orientation before the start of school, which is used for PD activities, and three PD days during the school year. The school invests 2.5% of its annual operating budget in PD, putting it at the higher end of investment compared to most U.S. schools (Basma & Savage, 2018). The investment in technology to support the current program also involves investment and training in videoconferencing technology.

Trade-offs

The current STEM PD lacks articulated outcomes and does not fully address the challenges that teachers face. Furthermore, the current STEM PD relies on U.S.-based, expert-driven sources, which may not recognize local knowledge and language and reinforce postcolonial patterns in international education.

Relationship to Leadership Approaches

Although encouraging teachers to lead workshops allows the distribution of leadership, without clear outcomes related to the STEM PD it impedes the transformational leader from inspiring a compelling vision for the program and a narrative for the school. Furthermore, a one-off workshop model lacks the continuity of the interconnected environment for teacher growth critical to professional learning (Justi & van Driel, 2006).

Selected Solution Strategy

Each solution strategy assessed requires time, human resources, money, or technology investments. Based on this assessment, the strategy that would encourage reflective learning, aligns with selected leadership approaches, addresses readiness, and challenges postcolonial patterns is a mentoring program. First, a mentoring program constructed with a high level of stakeholder participation will be able to meet the STEM teachers' specific needs (Dan & Gary, 2018), bringing congruence to the task and people elements of the organization. Second, mentor and mentee involvement in shared decision-making will address the inquiry question on teacher turnover. An additional benefit of shared decision-making is that it allows meaning-making to clarify STEM PD's complex vision and outcomes (Holmlund et al., 2018), which increases readiness (Avolio & Hannah, 2008). This option balances a teacher-driven approach with a clear vision and objectives, which the looser structure of CoP's may lack (Agarwal & Agarwal, 2016).

Having mentors and mentees be active participants in the learning will allow them to draw on their own beliefs, backgrounds, and culture. This will situate the strategy in the constructivist paradigm employed in this OIP (Irby, 2020; Pfadenhauer & Knoblauch, 2018) and mitigate the current Western-centric STEM PD content. By incorporating teacher backgrounds, this strategy addresses the second line of inquiry of disentangling NCIS from postcolonial practices. Therefore, this OIP will implement a mentoring program that has the potential to change the way that professional learning and growth look at NCIS. In addition, a monitoring and evaluation framework will be put in place to assess its effectiveness during implementation to increase the chance of success.

Inquiry Cycle

According to the change path model, in the institutionalization phase, metrics will need to be employed to frame and monitor the process from awakening to institutionalization (Deszca, 2020). This process will use a monitoring and evaluation framework incorporating research-informed causal relationships between program theory and logics (Markiewicz & Patrick, 2016). More importantly, the monitoring and evaluation will contribute to organizational learning by providing insight into program effectiveness and answering the evaluation questions. Markiewicz and Patrick's monitoring and evaluation framework establishes context and the theory and logic of the change to generate evaluation questions. These evaluation questions are the basis of the monitoring and evaluation plan, which is structured with the tools, roles, and timeline to collect, manage, and synthesize data, providing insight on program impact. Further elaboration on the monitoring and evaluation framework will be discussed in Chapter 3. In order to leverage the chosen solution strategy change leaders will need to fully understand the postcolonial landscape of international education and how this influences the change effort at NCIS.

Leadership Ethics and Decolonization Challenges in Organizational Change

As illustrated by the dualities framework in chapter 1, postcolonial patterns exist in international education and at NCIS. This section will discuss postcolonialism in Latin American history and its legacy in international education. Postcolonial patterns also shape STEM education, especially the assumptions about knowledge and the privileging of U.S.-centred STEM concepts. Furthermore, this section will discuss how solution strategies offer a chance to shift away from U.S.-centered PD through increased participation of teachers in program design and improved access for Spanish-only speaking teachers. However, before embarking on solution strategies, it is necessary to establish a specific understanding of the meaning of postcolonialism in the context of this OIP.

Postcolonialism

Postcolonial is a term that describes the global condition where cultural, political, and economic arrangements are the result of European colonialism (Tikly, 1999). The term *post* does not refer to the ceasing of this pattern after formal independence but rather to the continuance of economic and political dependency (Lavia, 2007; Loomba, 2015). A contemporary globalized world does not rely on direct rule; still, rich countries' political and economic agendas are imposed on poorer ones (Hébert & Abdi, 2013; Tarc & Tarc, 2015). Although sharing experiences with other regions, Latin America has a unique postcolonial history (Bortoluci & Jansen, 2013).

The Latin American Context

The Latin American historical context is different from colonial patterns in other parts of the world. Latin America experienced a comparatively long period of colonialization, around three hundred years. Colonialism led to land appropriation, religious hegemony, and forced labour (Mollett, 2017). Spanish colonizers mixed with Latin American–born Europeans creating a complex social and political hierarchy (Loomba, 2015). Only after the rise of England and France did Spanish power wane in the new world (Bortoluci & Jansen, 2013). After independence, locally born elites remained in power, sustaining colonial patterns, ideals, and practices. This transition ushered in a new and equally complex trajectory of postcolonialism in Latin America.

The different historical patterns mean that postcolonial discourse is unique when applied to the Latin American context (Bortoluci & Jansen, 2013). For example, geographic proximity to the United States meant that American influence quickly dominated the western hemisphere after Spanish independence. Moreover, as international education grew in the latter half of the twentieth century (Sylvester, 2005), the "pedagogic culture," the ideas, terms, and institutions, transferred from the dominant U.S. educational system to the Latin American international school context (Pozo & Ossenbach, 2011, p. 583).

Colonialism and Knowledge

Colonialism reshaped existing knowledge structures and marginalized local ways of seeing and knowing (Loomba, 2015). Far from an objective and value-free domain, science was used to reorder indigenous knowledge and assert that the colonized world was one of absence, requiring the application of European discovery and classification (Takayama et al., 2016). In this way, science and the imposition of European epistemologies were used to justify colonizer superiority. Furthermore, Western science portrays indigenous knowledge in binary terms. For example, science frames indigenous as older and Western science as modern, implying superiority (Carter, 2004). These conceptions of science and knowledge are the foundational structures on which schools in the colonial period were established and whose patterns continue today.

Postcolonialism and Education

Knowledge and power are linked to education, which is highly implicated in the continued domination of imperial structures of power (Rizvi, 2008). Education was central to the European administration of the colonies (Takayama et al., 2016). International education has been used as a colonial tool for proselytization, as a way to expand superpowers' sphere of influence during the Cold War (Tsvetkova, 2008), as an adjunct to development aid (Sylvester, 2005), and to promote a technical–economic agenda (Keller, 2015b). As a result, education experts and scholars have normalized Western enlightenment values and privileged the American education system's pedagogical theory and practices (Takayama et al., 2016).

International schools are often shaped by pragmatic outcomes, as discussed in Chapter 1, where graduates' success is determined by their ability to serve the labour force of the global economy (Lavia, 2007). These outcomes encompass international school curricula, pedagogy, and teacher PD that promote international diploma programs, English-language instruction, and Western-centric concepts of knowledge (Stier, 2004; Wilkins & Urbanovic, 2014). Although many school practices contribute to idealistic outcomes and align with a global civil society vision, when postcolonial patterns go unexamined, programs, and policies end up serving a monocultural and privileged agenda.

Western-Centric Ways of Seeing and Knowing

A postcolonial lens can be used to examine STEM PD practices. There are three themes to explore, the privileging of Western-centric ways of seeing and knowing the world, the reliance on U.S.-based STEM PD, and barriers to non-English speakers' access to STEM PD. The first assumption to be clarified is that Western knowledge production is an imposed colonial construct that marginalizes local belief systems (Loomba, 2015). Bickmore et al. (2017) determined that the languages, curricular patterns, and school organization were based on colonizers' conceptions. This can still undermine current approaches to education reform since local policymakers may be unaware of the colonial legacy or unable to influence the educational patterns currently in place (Nguyen et al., 2009). As seen through the dualities framework, international education and specifically American-aligned international schools are founded on the Western ways of seeing and knowing. Northern College International School is not any different.

Privileging U.S.-Based STEM PD

Northern College International School was founded in the 1960s with support from the U.S. State Department to provide education to the growing community of expatriate families working in the petroleum industry. These postcolonial patterns remain in place at NCIS. STEM is a continuation of progressive education and has its origins in the United States (Mohr-Schroeder et al., 2015). The STEM accreditation framework is based on a U.S. conception of global competitiveness and human capital development, as evidenced by standards referring to "workforce readiness" (Cognia, 2020b, p. 7). Northern College International School's partnership with U.S.-based PD providers is evidence that the STEM program privileges an American vision of STEM and that exclusive dependence on this model is flawed. Perhaps the most concrete proof of this is the language in which most STEM PD is provided.

Language

English is the lingua franca of higher education globally (Wilkins & Urbanovic, 2014), so it is understandable that parents of students in international schools value English instruction (Weenink, 2008). Tarc and Tarc (2015) point out that English-language fluency is a social marker of advantage in international school communities. Close to 95% of the NCIS student body's home language is Spanish. The school has set a policy that determines what subject areas are taught in English and at which grade levels; however, no similar policy governs teacher PD. As a result, Spanish-only staff often buddy with a bilingual staff member who provides interpretation when STEM PD workshops are in English. Nevertheless, dependence on solely English language resources creates barriers and inequity for staff who do not speak English and is one that organizational actors must take responsibility for addressing.

Responsibility of Organizational Actors

The school has a stated purpose of being a community with a global perspective and a vision for socially responsible graduates. As a school that purports to adhere to global civil society principles, it has a responsibility to seek equitable structures and practices. However, postcolonial patterns run deep and have shaped science education curricula (Carter, 2004) and professional development (Lavia, 2007). The school board of directors and the school director must exercise their responsibility to ensure that the school principles are reflected in practice. The leadership team, including STEM coordinators, can enact this change.

The most effective way for this OIP to challenge postcolonial patterns is to embed equitable practices in the solution strategy of this OIP. For example, it may be out of the scope of influence for leaders to change how English is valued in international education. Still, they can seek to provide STEM materials in Spanish. Additionally, encouraging translanguaging environments for mentor–mentee interactions will help to increase equity and teacher agency. Finally, STEM coordinators and the leadership team have a responsibility to leverage the narrative of postcolonialism to enact STEM PD more equitably.

Postcolonial patterns persist in Latin America, international education, and how STEM is enacted at NCIS. Western knowledge structures are legitimized through STEM; the teacher PD is U.S.-based and often given in English, excluding many staff members. Yet, NCIS purports to be a community with a global perspective, a vague term but one that implies promoting diversity. To address the second line of inquiry, the solution strategy must incorporate participant background and culture into PD in order to shift it away from exclusively U.S.-centred STEM PD. This will provide other forms of STEM meaning and enactment and promote learning and equity for all STEM teachers at NCIS.

Chapter 2 Conclusion

This chapter discusses how transformational leadership supports teacher growth, and how emergent distributed leadership models at NCIS can be leveraged to broaden stakeholder participation—both critical to addressing the PoP and aligned with constructivist ideas for learning and change. The change path model, complemented by Duck's change curve, addresses the type of change and focuses on the growth that needs to occur and embraces the complex nature of change. It can also increase readiness through clear communication, stakeholder consideration, and vision building. The critical organizational analysis uses a congruence, readiness, change path, and postcolonial lens to identify a need for better teacher preparation, a clearer PD vision, and eliminating barriers to STEM PD access. Overcoming these gaps requires a STEM teacher mentoring program that will change the environment where teachers learn and grow, clarify expectations and STEM outcomes, and break free from some of the persistent postcolonial patterns at NCIS. With a clear illustration of how the change will happen and what needs to occur, this OIP can turn to the implementation, evaluation, and communication of the change effort in Chapter 3.

Chapter 3: Implementation, Evaluation, and Communication

This final chapter will describe how the change path model guides the implementation of the mentoring program through the awakening, mobilization, acceleration, and institutionalization phases. Employing Markiewicz and Patrick's (2016) monitoring and evaluation framework and using current data collection structures at NCIS, will provide insights into program effectiveness during and after implementation. Next, this chapter will describe a communication plan that prioritizes the role of stakeholders and outlines the *why*, *what*, *who*, *for whom*, and *how* of the strategy. The change plan, measurement, and communication strategies work to provide a mentoring solution to support teachers as they implement STEM education at NCIS. Finally, this chapter concludes with a discussion of the importance of continuing to shift away from postcolonial patterns and how educators must develop their capacities to engage a more diverse population of students in STEM education. To begin, a discussion of the change implementation plan that will chart a pathway from awakening to institutionalization.

Change Implementation Plan

The solution strategy selected for implementation is the STEM teacher mentoring program. The mentoring program involves an experienced STEM teacher as a mentor and a teacher new to STEM as a mentee for the minimum duration of one school year. This strategy is grounded in a constructivist approach since it recognizes that mentors' and mentees' backgrounds, experiences, and beliefs are mediating factors in their professional growth. Furthermore, mentoring promotes reflective teacher learning (Fox & Wilson, 2015), localizes that learning in the NCIS context (Dan & Gary, 2018), and contributes to teacher retention (Ingersoll & Strong, 2011). The program's goals are to develop new STEM teachers' pedagogical skills (i.e., planning, teaching, assessing) and increase their confidence in teaching STEM. The mentoring program will start as a pilot and follow the change path phases of awakening, mobilization, acceleration, and institutionalization, complemented by Duck's (2001) change curve elements.

Awakening-Stagnation

Confirming the problem, identifying key stakeholders, and making a case for change are fundamental outcomes in the first phase of the change implementation plan and is projected to last 1-2 months.

Confirming the Problem

The change path model suggests assessing the problem by putting the data to work. Teacher perception data, discussed in Chapter 2, show teacher dissatisfaction with current PD and a desire for more relevant STEM PD. If the average teacher turnover rate for expatriate teachers is 27% to 38% per year, this means five to eight STEM teachers per year are entering the school and needing support. This shows that the problem will continue to grow each year without changes to the STEM PD.

Identifying Key Stakeholders

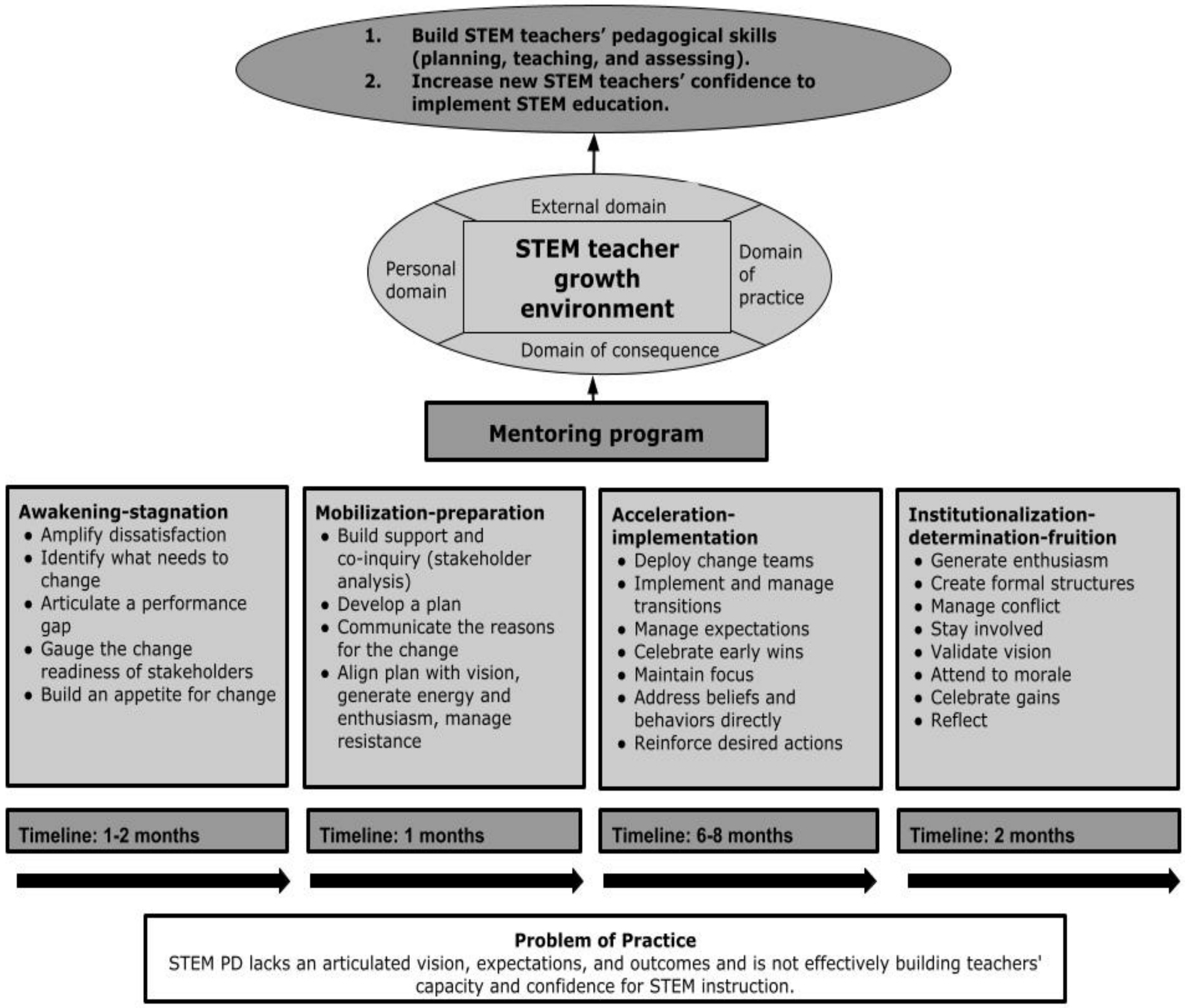
In this initial phase of change, the STEM committee at NCIS is a critical stakeholder group. The STEM coordinators chair the committee, which has the participation of experienced STEM teachers from different grade levels. Involving this group in the data collection and analysis will sharpen their appetite for change since engaging stakeholders as co-inquirers increases the collective ownership of the change implementation (Lofthouse et al., 2012). As the development of the mentoring program progresses, this inquiry shifts to participation in developing program logic and evaluation questions that will be used for program structure and monitoring. Since the number of stakeholders involved in the change process increases, so does the complexity (Deszca, 2020). Therefore, limiting the participation at this phase to STEM coordinators and two or three experienced STEM teachers will provide more face-to-face interactions critical to meaning-making and communication (Lewis, 2019). Ideally this phase and the next should occur in the last semester of the school year so the stage will be set to bring in new STEM teachers at the beginning of the next school year. With key stakeholders identified, a case for change can be made.

Making a Case for Change

A compelling change vision must be manageable, generate tangible outcomes, be easily understood, and inspire excellence (Deszca, 2020). Strategy maps make the problem explicit, promote reflection, and contribute to the shared understanding critical to distributed leadership (Armstrong, 2019). As seen in Figure 6, the STEM professional growth strategy map illustrates the major activities and timeline for each change stage and how this leads to increased teacher capacity and confidence. Making the cause-and-effect relationship clear, visible, and simple increases vision building and communication in change efforts (Lucianetti, 2010). Accompanying the information from the strategy map with a compelling narrative about the urgency of providing effective STEM PD will strengthen the change vision and mobilize key stakeholders (Deszca et al., 2020).

Figure 6

Change Path Strategy Map



Mobilization-Preparation

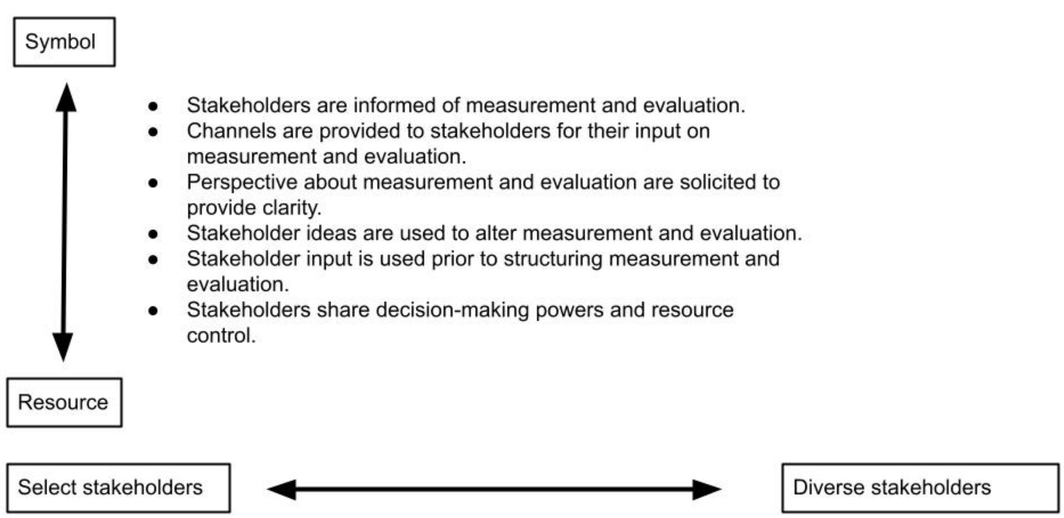
During the mobilization stage, a thorough understanding of stakeholder values and roles will inform strategies to increase their participation and commitment to articulating the plan. Ideally, this phase occurs prior to the beginning of a new school year in order to launch the pilot as new STEM teachers enter the school. Also, clear communication of the change plan will provide clarity, receptiveness, and enthusiasm at this stage.

Expanding Stakeholder Participation

As the number of people involved in change increases the ambiguity, complexity, and time needed for change also increases (Deszca, 2020). Therefore, the participation is still limited to STEM coordinators and a few experienced STEM teachers, but with a higher level of involvement allowing more input opportunities (Lewis, 2019). Figure 7 illustrates the two dimensions of stakeholder participation: (1) select versus diverse stakeholder participation and (2) stakeholders as a resource versus symbolic. The mentoring solution strategy involves limited selected stakeholders (e.g., mentors, mentees, STEM coordinators) but as resources (e.g., providing them with a high level of decision-making responsibilities). With an understanding of the context, parameters, and approach to stakeholder participation, an exploration of the program logics can occur.

Figure 7

Stakeholder Participation Array



Note. Adapted from Lewis, L. (2019). *Organizational change: Creating change through strategic communication* (2nd ed.). Wiley Blackwell.

Analysis of stakeholder values, their role in policy change, and alignment with international school outcomes will provide better policy alignment (Honig, 2002). Table 2 illustrates how each stakeholder group has different values and aligns to different outcomes, often based on their role in the policy change. For example, according to Ball’s (2011) typology of policy actors, the STEM coordinators and committee members play the role of STEM policy *narrators* and *entrepreneurs*. Therefore, developing the plan with key stakeholders, involving them with interpretation, meaning-making, and shared decision-making will provide better policy alignment as they plan and implement the mentoring program (Fasso et al., 2016; Honig, 2002).

Articulating the Plan

In the mobilization stage, the STEM coordinators and committee will draft an implementation plan that identifies stakeholders, outcomes, measurement tools, resources, and a timeline (Deszca, 2020). Results must be aligned with organizational goals and planned with the end in mind, allowing for better organizational support and identifying desired educator knowledge and skills (Guskey, 2014). Once outcomes are established, change leaders will communicate the significant tasks and objectives of each stage of the change process, including the resources needed, stakeholders involved, and a timeline.

Communicating the Plan

In this stage of the change process, an articulated communication strategy should be implemented. Communication will convey why the change is necessary, what will be communicated, who will communicate, who the different audiences are, and how the change will happen (Beatty, 2016). More specifically, the plan should address the nature and complexity of the change, the benefits to the organization and individuals (Deszca, 2020), and how it generates enthusiasm, addresses resistors, and seeks support (Duck, 2001). At NCIS, the communication will focus on the needs and the benefits of the change for teachers—important in making a strong case for change (Armenakis & Harris, 2017). Northern College International School has several formal and informal communication channels, including social media, coffees with the director, and faculty and department meetings, that provide two-way communication opportunities shown to be highly effective at conveying a message (Klein, 1994; Lavis et al., 2003). The communication plan will be elaborated in more detail later in this chapter; at this point the plan moves into the acceleration phase.

Acceleration-Implementation

The acceleration stage requires the execution of the implementation plan and is the longest phase of the four. This phase should commence at the beginning of the school year when new STEM teachers require orientation, and when their needs align with the mentoring program's outcomes. The objectives at this stage are for stakeholders to know the mentoring policy, mentor recruitment to begin, resources to be allotted, and orientation to be provided for mentees and mentors.

Deployment

Once the change plan is articulated and communicated, the recruiting and orientation of mentors may begin. STEM coordinators and committee will create a profile and criteria for the selection of mentors based on three research-supported principles: mentors do not need to be experts (Hargreaves & Fullan, 2000), they must show a commitment to reciprocal learning and be receptive to reflective dialogue (Kilpatrick & Fraser, 2019).

At this stage, the scope of the program should be determined. Based on the readiness assessment, it would be prudent to limit the scope to five mentor–mentee pairs for this first cycle. Then mentor recruitment can begin and orientation for mentors and mentee pairs will take place. Most mentor programs train only the mentor, excluding the mentee and limiting program impact

(Aspfors & Fransson, 2015). The mentor program at NCIS will include orientation for both mentor and mentee and involve collaborative inquiry, known to encourage experimentation (Ainscow, 2016). When participants are invited to integrate their ideas into the change plan, they become more committed to the change (Napier et al., 2017). Finally, a calculation of the PD costs to train mentors and the stipend offered for participation will determine the financial costs at this stage.

Managing Transitions

Implementing the mentor program will require the time and attention of STEM coordinators, teachers, and principals, so managing transitions is essential. The scope of the change, the number of individuals involved, and the nature of the intended change all contribute to the increased complexity of the effort (Deszca, 2020). Managing transitions means ensuring that the school can continue to operate successfully while key leaders implement change. As discussed in Chapter 2, time constraints impede teacher and coordinator readiness. Limiting the program scope to five mentor–mentee pairs, at least for the first cycle, lowers demand on STEM coordinator time, reduces the program's costs, and allows the program to be tested and improved on a small scale. Anderson and Sice (2016) found that voluntary small-scale pilot programs engendered trust, involvement, commitment, and subsequent action among all stakeholders. A smaller scale with fewer program participants means more attention to their beliefs and behaviours, better-quality communications, and resistance reduction strategies that increase openness and commitment to change (Napier, 2017; Rafferty et al., 2013).

Addressing Beliefs and Behaviour

Engaging the STEM coordinators and committee in collaborative inquiry, ensuring participating mentors are clear on their commitment, limiting the scope of change, and providing a clear vision for change promote readiness (Napier et al., 2017; Rafferty et al., 2013).

Nevertheless, resistance may occur at this phase. Resistance can be defined as negative attitudes toward change stemming from affective, behavioural, or cognitive components (Oreg, 2006). Although contested (see Repovš et al., 2019), resistance can be seen as the opposite of readiness and a plan to directly address these beliefs and behaviours is crucial.

Duck (2001) claims that change processes follow the rule of thirds. One-third will see the change as irrelevant. One-third will be believers, and one-third will be resistors. Highlighting the transformational nature of the change and how it will benefit the school and the teachers is a crucial message for those who see change as irrelevant (Rafferty et al., 2013). The resistant third can be converted by addressing behaviours over beliefs (Dudar et al., 2017). This means that change leaders should be asking recipients to suspend belief temporarily, engage in the change action, then reflect on the impact of the change. This strategy is consistent with the STEM teacher professional growth environment, which assumes that teacher learning comes *after* enacting the new strategy and emerges from reflection on its impact (Clarke & Hollingsworth, 2002). Although implemented, the change is still tentative and will need to be prioritized, evaluated, and scaled up during the institutionalization stage.

Institutionalization-Determination-Fruition

During the institutionalization stage of the change path, the outcomes are to maintain enthusiasm, evaluate the pilot program, and scale up to the full implementation. There may be overlap in the completion of the previous stage and this one; however, evaluation of the program and growing the scale of the pilot should be carried out prior to the end of the school year.

Maintaining Enthusiasm

As initial enthusiasm for the program wanes and other priorities emerge, the leader should aim to maintain momentum and confidence by managing priorities, reprioritizing organizational commitments, engaging in reflective conversations, and celebrating successes

(Deszca, 2020). In this stage, transformational leadership's focus on learning and distributed leadership's emphasis on shared responsibility can be leveraged to institutionalize the change. Spreading responsibilities over several individuals—the school director, STEM coordinators, and experienced teachers—will provide the time to interact continuously with mentor–mentee teams. Increasing one-on-one interaction raises the relational trust critical to the mentorship program (Aspfors & Fransson, 2015). In addition, it will allow leaders to be in tune with teachers' emotions throughout the change (Duck, 2001).

Evaluation

Evaluation will be discussed here but monitoring and evaluation must be embedded in every change phase. Markiewicz and Patrick's monitoring and evaluation framework will be used since it highly values stakeholder participation. The STEM coordinators and experienced STEM teachers will participate in constructing evaluation questions. The monitoring and evaluation program will be structured on program theory, NCIS context, and program logics. Surveys, observations, and interviews will be tools to collect data on program implementation. A fuller discussion of monitoring and evaluation will occur in the next section.

Scaling to Full Implementation

As the institutionalization stage concludes, it should be seen as the beginning of the following change cycle. The STEM coordinators and committee will need to capture reflections using the measurement tools discussed and transform data into judgements to answer evaluation questions (Markiewicz & Patrick, 2016). These judgements inform the lines of inquiry and lead to organizational learning and program improvement. In addition, validation or feedback from a third party is valuable (Deszca, 2020). Finally, although NCIS does not have a school accreditation visit scheduled until 2024, data and artifacts of this change effort should be collected. They can provide evidence of achieving Cognia's school quality standards.

Deszca, Ingols, and Cawsey's (2020) change path model, complemented by Duck's (2001) change curve, provide a framework for the change plan for implementing the STEM teacher mentoring program. Transformational leadership behaviours, like focusing on collective inquiry, are employed in the awakening and mobilization stages to commit stakeholders to the need and vision for change. Accelerating change requires distributing the leadership across STEM committee members to recruit mentors and maintain frequent contact to address their emotions as they go through the transition. The learning for the STEM teachers is not knowledge transfer but mutual growth as both mentor and mentee learn together, thus altering traditional patterns of postcolonial PD models. A monitoring and evaluation framework will be used throughout the change path to make judgements and inform future iterations of the mentoring program. The change implementation plan offers a clear pathway for implementation, upon which the communication, and monitoring and evaluation plan will be based.

Change Process Monitoring and Evaluation

Beyond measurement, the monitoring and evaluation plan generates insights during implementation, provides evidence of program effectiveness, and answers evaluation questions, thus contributing to organizational learning. Northern College International School adheres to a school quality and accreditation framework that requires the collection of stakeholder perception and classroom observation data. Leveraging these structures and data will provide evidence of the mentoring program's effectiveness. This plan complements these institutional data with participant reflections of evaluation questions collected through interviews. Markiewicz and Patrick's monitoring and evaluation framework is chosen since it incorporates research-informed causal relationships into its model. To follow is a discussion on the appropriateness of this model compared to two other commonly used models for monitoring and evaluation and a description of the activities in each phase of the monitoring and evaluation plan.

NCIS's Approach to Monitoring and Evaluation

Before discussing monitoring and evaluation, it is important to outline the current assumptions behind collecting institutional data at NCIS. Cognia accredits the school and visits every five years and applies a standards-based framework to measure school improvement and effectiveness (Cognia, 2019). Although accreditation legitimizes school offerings (Acosta, 2020), one-size-fits-all frameworks are often based on Western-centric concepts, which do not consider local differentiating elements and ignores the professional judgement of teachers (Fontenelle-Tereshchuk, 2014). Since incorporating a program participant's background, language, and culture in its design is a primary premise of this OIP, then the monitoring and evaluation framework must go beyond collecting institutional data. The monitoring and evaluation framework must include tools to collect participant perceptions and reflections on program effectiveness. There are many tools to measure program implementation, in the next paragraph two additional tools were assessed but deemed inappropriate for this setting.

Plan-Do-Study-Act and Concerns-Based Adoption Model

Before settling on the chosen monitoring and evaluation framework, two other approaches were considered: the Plan-Do-Study-Act (PDSA) cycle and the concerns-based adoption model (CBAM). The PDSA model, based on quality control management (Laverentz & Kumm, 2017), mitigates uncertainties, exposes new opportunities, and promotes strategy evolution (Pietrzak & Paliszkiewics, 2015). The strength of this model is its cyclical nature, yet a study carried out by Taylor et al. (2014) found that only 20% of implementations cycled more than once. The potential lack of sustainability is a weakness of the PDSA cycle.

A second model to receive consideration is the CBAM, which seeks to understand concerns, questions, and perceptions while adopting new practices (Roach et al., 2009). Min (2017) found that the CBAM overgeneralizes the developmental progress of adopters and fails to consider the idiosyncrasy of the change process. Although CBAM provides insights to leaders in understanding the fidelity and sustainability of the effort, it is a tool, not an approach. Neither of these models matched the sophistication of the focus on inquiry of Markiewicz and Patrick's monitoring and evaluation framework.

Monitoring and Evaluation Framework

Unlike the PDSA and CBAM models, Markiewicz and Patrick integrate many complex processes under a common framework designed to answer a set of evaluation questions. This framework anchors the plan and ensures that each step leads to the main purpose of monitoring and evaluation (Bhawra, 2019). In addition, their model prioritizes theory informing practice, a foundational principle of OIPs (Archibald, 2013). Furthermore, the model encourages the development of research-informed causal relationships between the solution strategies and the intended results, something frequently missing in mentoring programs (McQuillin et al., 2020). Not only is this an integrated framework but it also aligns with learning theories that inform this OIP. Markiewicz and Patrick assert that this model is compatible with the constructivist views on learning and professional growth used in this OIP. Additionally, this model involves stakeholders in each phase, starting with developing tools, elaborating inquiry questions, making meaning of key concepts, and analyzing data (Tengan & Aigbavboa, 2017). Finally, valuing and incorporating teacher backgrounds counterbalances the inherent postcolonial patterns evident in the accreditation-oriented measurement tools used at NCIS. Although coherent with the theoretical framework, data collection methodology, and commitment to teacher participation, there are criticisms that must be considered.

Even though the framework aligns with several elements of this OIP, there are criticisms. First, Bhawra (2019) points out that the model is not a comprehensive guide to data analysis and synthesis. However, Markiewicz and Patrick never claim that data analysis or synthesis is their goal. A second criticism is that the model assumes that program theory has a direct cause-and-effect relationship with program logics. However, Borg's (2018) study on the impact of PD found logics are shaped not only by theoretical considerations but also by more practical matters of time, funding, and expertise. To mitigate this weakness in the model, realist evaluation, which assumes multiple contextual factors must also be monitored, will inform the evaluation plan (Porter, 2015). The following sections will discuss the monitoring and evaluation framework phases as applied to the STEM mentoring program.

Introductory Phase: Context

The first phase of the model establishes the context, resource parameters, and approach to stakeholder participation. The context of NCIS influences the decisions taken throughout implementation (Hallinger & Leithwood, 1996). With the low level of intentional readiness due to the increased workload on teachers during the pandemic, existing data sources are preferable to inventing new ones. Also, using existing school data allows the researcher to collect data in less obtrusive ways and to maintain ethical considerations (Busher, 2012). Principals carry out classroom observations continuously, and the school applies stakeholder surveys yearly. This will permit the collection of salient data for the impact of the mentoring program on teacher learning and instruction.

Program monitoring tools, such as individual interviews of participants, are not widespread and will need to be developed. Since STEM coordinators are bilingual (English–Spanish), the interviews may be carried out in either language, promoting translanguaging, which demonstrates an appreciation for the perspective and backgrounds of all teachers (Briceño et al., 2018). This also shifts practices away from English as the lingua franca of international education (Wilkins & Urbanovic, 2014).

At this phase, the STEM coordinators and committee will create a list of existing data sources to be employed. External school accreditation reports recognize a high level of stakeholder participation at NCIS (Cognia, 2019). Leveraging this practice will be critical; however, the nature and diversity of participants will need to be determined. Informing this selection of participants will be an assessment of stakeholder values and roles (see Table 2).

Program Theory and Logic

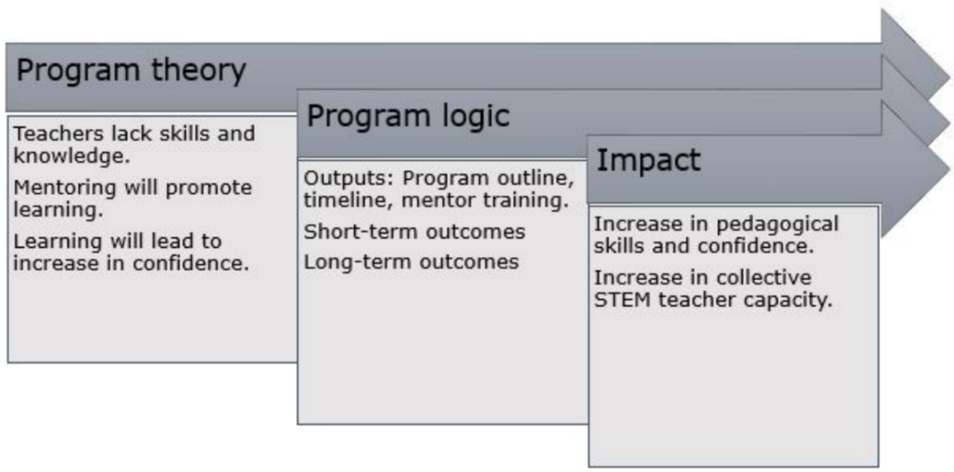
The next phase is establishing the mentor program theory and logic. Program theory outlines the empirically informed assumptions of the model. Program logic maps the steps involved in the plan to produce the desired effects (Markiewicz & Patrick, 2016). The first assumption is a constructivist approach to learning, where learners' beliefs, experiences, and culture affect their knowledge construction (O'Dwyer, 2018). Another assumption is that professional growth occurs when teachers enact new strategies and reflect on their outcomes (Clarke & Hollingsworth, 2002). The final assumption is that allowing teacher backgrounds to mediate the learning is a mechanism to disentangle PD practices from postcolonialism and provide more relevant learning for STEM teachers.

Based on these three theory-informed assumptions, causal relationships between inputs, actions, and intended results can be established (Markiewicz & Patrick, 2016). Figure 8 illustrates the program theory assumptions, which lead to new skill acquisition, professional growth, and confidence. This model also shows how teachers' participation in program design provides a PD model that shifts away from the exclusive use of English-only, U.S.-based, and expert-driven STEM PD. Program theory informs the logics of the mentoring program activities involving mentor–mentee interaction and reflection.

Actions in this stage include reviewing the program theory with STEM coordinators and committee to test assumptions and ensure it aligns with the NCIS context and values. In addition, involving participants at this stage will equip them with a greater understanding of the principles and theoretical framework of the change, increasing readiness and giving them the skills to navigate the change (Havice et al., 2018).

Figure 8

Mentoring Program Theory and Logics



Note: Adapted from Markiewicz, A., & Patrick, I. (2016). *Developing monitoring and evaluation frameworks*. Sage Publications.

Evaluation Questions

Program theory and logics provide a springboard for the development of evaluation questions. Drawing on the PoP, available data, current research, and stakeholder experience, stakeholders develop questions from five domains: appropriateness (i.e., contextual suitability), efficiency (i.e., use of resources and delivery), effectiveness (i.e., achievement of outcomes), impact (i.e., expected and unexpected results), and sustainability (i.e., maintaining benefits of program) (Markiewicz & Patrick, 2016).

Emphasizing a questioning approach that challenges learned truths is a practice intended to interrogate postcolonial assumptions (de la Garza, 2021). The STEM coordinators will develop the evaluation questions (see Appendix F) and facilitate stakeholder engagement throughout their consolidation. This dialogue provides opportunities to explore possible questions of mentor program participants, thus anticipating concerns that may affect program fidelity and sustainability (Roach et al., 2009). Furthermore, stakeholder input, time, data, and availability help determine the scope and quantity of questions. Final evaluation questions will then serve to construct the monitoring and evaluation plan.

The Monitoring and Evaluation Plan

The evaluation plan must be grounded in the program theory and logic so that the methodology and tools generate the appropriate data that are suitable for synthesis and judgements (Markiewicz & Patrick, 2016). The monitoring and evaluation plan includes the monitoring focus, evaluation focus, tools, and responsibilities needed to answer the evaluation questions. For example, *to what degree are the mentors and mentees adhering to programmed activities?* is focused on participant behaviour and fidelity to planned activities (see Appendix F). This evaluation question will also require developing a survey and interview tools and has been assigned to the STEM coordinators. The different tools allow for the impact of the mentoring program to be defined in various ways to include a range of cognitive, affective, and behavioural outcomes affecting participants at different points in time (Borg, 2018). This exercise can be repeated for each evaluation question.

One of the criticisms of this monitoring and evaluation framework is that program logics are not only shaped by program theory but also by contextual constraints (Borg, 2018). Therefore, a realist evaluation approach can be employed, which considers the how, why, and where of implementation effectiveness (Catton, 2020). Realist evaluation assumes that effects rarely result from a singular cause and that multiple contextual factors must be monitored (Porter, 2015). This approach is selected because context matters in this OIP and results may differ for participants based on their own beliefs, experiences, and culture (Thomas et al., 2015).

Furthermore, a focus on context counters the standardized evaluation paradigm inherent in school accreditation frameworks. Finally, realist evaluation takes contextual factors seriously, where individuals are active in the program's success. Duck (2001, p.167) calls this "inclusive strategic planning," which can be extended to involve participants in data collection and analysis.

Data Collection, Management, Analysis, and Synthesis

The monitoring and evaluation plan identifies the data and tools needed to answer the evaluation questions. This next step will outline how the data will be collected, how data will be managed, and how data will be synthesized. It is most ethical and practical to employ data collected routinely by NCIS, ensuring ethical considerations such as alignment with learner needs, institutional priorities, and the promotion of collective inquiry (Lofthouse et al., 2012).

Surveys will gather data on the first component of realist evaluation, *observable context* (Greenhalgh & Manzano, 2021). These factors include mentee grade level, program leadership, mentor PD, and the time provided for mentor–mentee interaction. Interviews will collect data on the second component of realist evaluation, *dynamic context*, including factors such as mentor–mentee disposition, previous experience with STEM and mentoring programs, and time spent on mentoring activities.

Google Forms is a platform routinely used at NCIS and can be used to collect and store data from surveys and interviews. In addition, classroom observational data can be collected and analyzed using the software provided by Cognia, which permits aggregation of multiple observations and filtering by domains, such as digital integration, active learning, etc.

It is in this phase that evaluators begin to form judgements. It is accepted that judgement is formed when values, beliefs, and expectations intersect with knowledge, experience, and practice (McDavid et al., 2013). When knowledgeable stakeholders make judgements, their inferences answer the evaluation questions. The process for arriving at conclusions involves reviewing the evaluation questions, analyzing the synthesized data, making evaluative judgements, and arriving at evaluative findings. This leads to organizational learning.

Learning, Reporting, and Dissemination

Conclusions will lead to powerful learning if the insights can be effectively disseminated. The first step is to translate these insights into lessons and recommendations for program leaders to inform program improvement and redesign (Markiewicz & Patrick, 2016). The learning contributes to the collective capacity of those involved in structuring the mentor program and is a key outcome of transformational leadership (Thoonen et al., 2011). Since the mentoring program is in the pilot phase, the two most critical evaluation questions are effectiveness (i.e., whether the program delivers results) and sustainability (i.e., will these benefits transfer to a full-scale model). This learning discussion on the dissemination comes in the next section on communication. Still, it is essential to note that the target audience for this is the current participants and those who will be influential in the next mentoring program cycle.

Planning for Implementation of the Monitoring and Evaluation Framework

Finally, a work plan for the implementation will be constructed using a chart to visualize the timeline, tasks, and responsibility (see Appendix G). Additionally, resources and PD for data collection need to be identified in this phase. For example, stipends for mentors mean more effective mentoring (Richmond et al., 2017). Finally, a review of the implementation will also need to include the effectiveness of the monitoring and evaluation framework in generating the understanding that leads to learning.

Markiewicz and Patrick provide a model for monitoring and evaluating the mentoring program's effectiveness by exploring evaluation questions. For example, does mentoring offer a conducive environment for new STEM teacher growth? Does the program provide a learning environment that recognizes teacher beliefs, experiences, and attitudes? Driven by program theory and logics, the causal relationships between actions and outcomes generate evidence used to answer these evaluation questions. Answering these questions provides the framework and insights that lead to program improvement, contributes to individual and organizational learning, and provides important insights to guide the communication strategy.

Communicating the Need for Change and the Change Process

This section outlines a research-informed communication plan, which employs a model that prioritizes the role and voice of teachers. When used in combination with transformational leadership, the tenets of this model represent a shift away from some of the postcolonial practices of traditional STEM PD. The second part of this section outlines why the change needs to happen, what will be communicated, by whom and for whom, and how this communication will occur. It will also discuss how communication effectiveness will be measured and how celebrating the achievement of milestones can energize those involved in change.

Why Communication is Important

Much is written about the importance of communicating change. Almost three decades ago, Klein (1994) reported that many change efforts fail because not enough strategic thought is given to communicating the rationale and impact of change. Unfortunately, change leaders have not heeded this warning. The literature continues to be replete with accounts of ineffective communication (Salem, 2008) and leaders over-focusing on implementers rather than stakeholders (Lewis, 2019). This research points to a lack of consideration given to communication or offered as an afterthought.

When planned properly, communication can be used with transformational leadership to inspire teachers to commit to the change vision, and increase satisfaction, innovation, and program improvement (van Dierendonck et al., 2014). In addition, prioritizing stakeholder values, culture, language, and belief in the communication strategy will broaden participation and increase sensemaking, critical to building teacher capacity (Castro Superfine & Li, 2014). Therefore Lewis's (2019) communication framework will be employed to map the NCIS stakeholders, their sensemaking, relationships, and role in strategy, and to address concerns about the mentoring program.

Lewis's Change Process in Context of Stakeholder Communication

Lewis's change process in the context of stakeholder communication includes four components: antecedents, strategy, concerns/assessment/interactions, and outcomes. Each element contains concrete and observable factors that interact with each other and contribute to desired outcomes (see Figure 9). Lewis's model prioritizes the role of stakeholders over implementers in the communication plan. This makes it an appropriate model for this OIP since stakeholder participation is a transformational leadership behaviour and a strategy to address the lack of relevancy in STEM PD.

The benefits of focusing on stakeholder communication has empirical support. Beatty (2016) stresses knowing stakeholder values, issues, and valence, and tailoring messages to each group. In addition, Rucchin (2022) suggests that change must address stakeholder concerns and Lavis et al. (2003) highlight interaction with stakeholder groups as an effective strategy to articulate change efforts. Communication can also increase the emotional commitment to the change (Ouedraogo & Ouakouak, 2018). Thus, stakeholder consideration, alignment with the leadership approach, and empirical support make this model suitable for framing the communication plan.

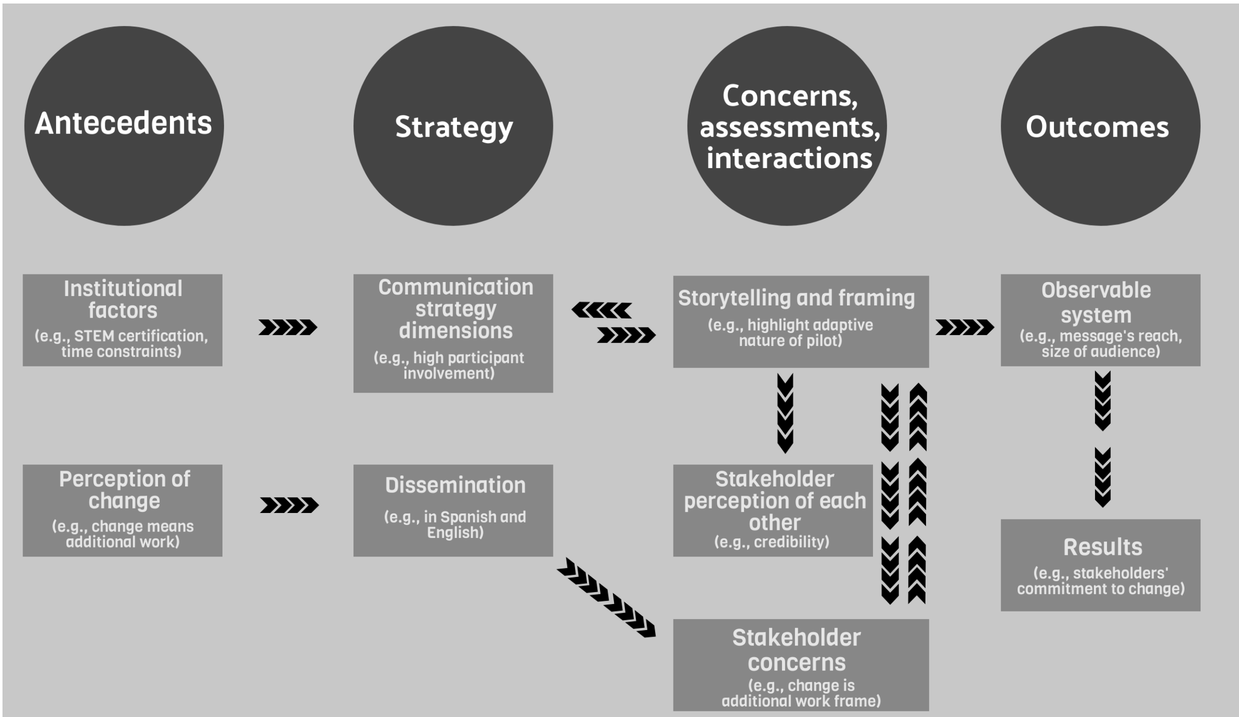
The communication model requires an understanding of stakeholder perception of change. For example, at NCIS, several stakeholder groups may be understood using Ball's (2011) typology of roles. Ball suggests that when the policy is enacted, stakeholders may take the role of narrators, entrepreneurs, receivers, transactors, or policy outsiders. But, of course, stakeholder groups are not monoliths and each group may span different policy roles (Connolly et al., 2011). This runs counter to Lewis's assumption that stakeholder values can be identified and broadly applied. To address this weakness in the communication framework, the mentor program at NCIS will begin on a small scale to allow change leaders to gather more specific information on individual program participant values and needs. Thus, avoiding the assumption that all stakeholders share the same concerns. Still, context is important and so Lewis's model begins with antecedents.

Antecedents

Lewis's model starts with antecedents, the institutional contextual factors and the perception of change that contribute to stakeholder sensemaking (see Figure 9). For example, at NCIS, antecedents such as the STEM certification as a U.S.-based conception of STEM education and the time constraints of teaching during the pandemic have shaped teachers' views of STEM PD. Additionally, the language of the recipient is a major consideration. These views and an evaluation of stakeholder values (see Table 2) provide the individual consideration important to transformational leadership (Northouse, 2019) and the development of a communication strategy.

Figure 9

Change Process in Context of Stakeholder Communication



Note. Adapted from Lewis, L. (2019). *Organizational change: Creating change through strategic communication* (2nd ed.). Wiley Blackwell.

Strategy

Stakeholder antecedents inform strategy and lead to the decisions regarding the dissemination and dimensions of communications. For example, to increase teacher participation, mentors and mentees are invited to assist in developing the program activities and evaluating the program. These expectations will need to be made clearly and persuasively for this stakeholder group (Armenakis & Harris, 2001). In addition, a different message can be constructed for nonparticipating stakeholder groups. Differentiating messages for program participants, nonparticipants, or other school constituents increases stakeholder engagement (Beatty, 2016; Salem, 2008) and aids in storytelling and framing.

Concerns, Assessments, and Interactions

Next in the model is how communication strategies impact the concerns, interactions, and framing of the issues. Storytelling and framing of the change narrative can influence stakeholders' perception of each other and their concerns. The way the change narrative is shaped by, and shapes, stakeholder concerns, is illustrated in Figure 9. Stakeholders' perception of each other is essential. Beatty (2016) and Lavis et al. (2003) agree that credibility is the most crucial characteristic of being influenced by others. In the NCIS context, the STEM coordinators and experienced STEM teachers are credible for their knowledge of STEM pedagogy, the support they provide to teachers, and their understanding of the micropolitics in the change environment (Fasso et al., 2016). As a result, they are influential opinion leaders and can determine how individuals frame the issues.

Lewis's model illustrates how storytelling and stakeholder concerns impact observable outcomes and program results. If stakeholders frame mentoring activities as constructive ways to promote learning, program acceptance will follow. Individuals selectively encode events, assigning more or less importance to elements based on their previous experiences and beliefs (Fiss & Zajac, 2006). Change leaders who know stakeholder group values, roles, and concerns can influence the framing of change elements by articulating a specific version of reality (Lewis, 2019)—thus, enabling the STEM coordinators and experienced STEM teachers to act as opinion leaders.

For example, at NCIS, teacher readiness and concerns about time constraints will mean that any change will be viewed through a lens of investment in time. Therefore, teachers may frame any change as additional work. To shift this frame, leaders must directly confront the time commitment by clearly articulating expectations regarding hours of training, number of mentor–mentee meeting sessions, and interviews and surveys for program monitoring. At the same time, change leaders must highlight the adaptive nature of the pilot, stakeholder involvement in planning, and most importantly, according to Armenakis and Harris (2001), the benefit to the teacher. This will shift the narrative from a time constraint frame to a frame where participants are given an active role in maximizing the program's benefits while optimizing time investment. In addition to evaluating results of the mentoring program, it is crucial to measure communication outcomes.

Outcomes and Results

The communication strategy should be measured to ensure that the tactics employed impact the observable system and achieve the intended results. Social media and electronic communications provide easy ways to measure the reach and engagement with messages (Rucchin, 2022). As discussed in the monitoring and evaluation section, evaluation questions from the effectiveness domain can be used to measure communications. For example, *to what extent is the communication plan committing teachers to the change effort?* frames the communication tactic. To answer this question, the program announcement should be sent through electronic channels and hopefully reiterated in two-way communication settings to reach the maximum intended audience. This evaluation question focuses on monitoring (measured by the size of the audience receiving the message) and evaluation (measured by resulting interested participants). In this way, evidence can be gathered to answer this evaluation question.

Stakeholder Voice, Transformational Leadership, and Postcolonial Patterns

Lewis's framework aligns with the transformational leadership approach and the shift away from postcolonial patterns in this OIP. Acknowledging the social dynamics and relationships between stakeholders is a transformational leadership behaviour and contributes to increased teacher motivation and satisfaction (van Dierendonck et al., 2014). Furthermore, as mentor program participants engage in sensemaking and storytelling, the program is modified to reflect the teachers' background, culture, and beliefs. This contributes to reshaping Western knowledge structures inherent in STEM education and based on colonial epistemologies (Loomba, 2015). Furthermore, engaging change recipients as active, rather than passive participants decolonizes the traditional communication approach that limits teacher agency (Dutta, 2015). Finally, tailoring messages to audiences allows the implementers to use the language of the recipients, dismantle the often-unquestioned use of English as the lingua franca of STEM PD, and engage participants in their mother tongue. A stakeholder-focused communication strategy means engaging in transformational leadership behaviours and shifting STEM PD away from its postcolonial patterns. It informs the communication plan's *why*, *what*, *who*, *for whom*, and *how*.

The Communication Plan

Lewis's model describes the strategy as decisions taken around dimensions of communication and dissemination. A communication plan follows, based on Beatty's (2016) research explaining the reason for the change, what will be communicated, by who, for whom, and how the difference will develop. This approach is based on three assumptions. First, lack of communication contributes to negative responses to change (Armenakis & Harris, 2001). Second, effective communication is correlated with change success (Beatty, 2016). Third, substantial change requires second-order learning and a high level of communication (Salem, 2008). Based on these assumptions, the following sections address the communication plan's why, what, and how.

Why the Change?

The first phase of the plan needs to make a case for change (Armenakis & Harris, 2017), articulate a clear vision for the future (Deszca, 2020), and explain what that future will look like (Beatty, 2016). Rucchin (2022) suggests that a small group of key stakeholders, including principals, STEM coordinators, potential STEM mentors, and the school's communication office, should be involved at this point. Stakeholder antecedents, internal data, external data, and change drivers, discussed in Chapter 1, may be used to make a case for change. This will illustrate the gap between new STEM teachers' capacity and efficacy and the pedagogical skills needed for effective STEM instruction, with mentoring the most appropriate strategy.

What Should be Communicated?

The second phase of the communication plan is to establish what message should be communicated, by whom and to whom. Crafting a clear message tailored to individual stakeholder audiences and effectively communicating requires expertise (Sutherland & Yoshida, 2015). Northern College International School has a communications office and involving expertise from this department will increase the likelihood that the message is actionable, data-informed (Lavis et al., 2013), credible, tailored to different audiences, and continually communicated throughout the change effort (Klein, 1994). The critical elements of the change message are

- current STEM PD is not meeting the needs of STEM teachers,
- mentoring is a research-supported practice that promotes teacher growth through collaboration and reflection,
- teacher participation and input are valued and needed at all stages of implementation, and
- mentoring provides a contextualized STEM PD model that shifts away from postcolonial patterns.

This is the change message that should be communicated through various communication channels.

This phase also requires the identification of who will deliver the message. As previously discussed, STEM coordinators and experienced STEM teachers hold the most credibility in STEM at NCIS. Finally, the communication channels, message recipients, and message need to be considered using the change path milestone (see Appendix H). Potential participants in the STEM mentoring program would be the primary audience; however, the message should be differentiated for mentees and mentors since personal valence and what they will get out of the change may differ (Armenakis & Harris, 2001).

How will the Information be Communicated?

The third phase is how the information will be communicated. What communication channels are currently in place, what results will be sought, how will they be measured, and how can milestones be celebrated? Since the mentoring program is limited to a pilot, the number of key stakeholders is limited. This will allow for face-to-face communication channels to be employed, a practice recognized by the research as increasing the collective and dynamic process needed for successful communication (Ocasio et al., 2018). This also allows for tailoring the message, the message being delivered in the language of the NCIS teachers, and opportunities for an adaptive approach to communication strategy.

Communication goals need to be established in this phase. Measurements should be specific to each audience. For example, at NCIS, communication with mentor program participants may be measured through mentor participation, quality of mentor–mentee relationships, and adherence to program activities. Evidence of these behaviours can be collected through participant surveys and structured interviews, a practice outlined in the monitoring and evaluation section.

Path of Change, Milestones, and Wins

As the change passes through the awakening, mobilization, acceleration, and institutionalization phases, celebrating milestones is important since initial enthusiasm may wane as other priorities emerge (Deszca, 2020). Duck (2001) points out that the change phases may not have a clear and definite end and beginning and suggests that change leaders instead mark important milestones along the path. Since change can be rejected even in the latter stages of implementation (Armenakis & Harris, 2001) and attentiveness to teacher feelings can engender relational trust (Sutherland & Yoshida, 2018), celebrating milestone achievement is crucial.

Several milestones can be identified in the change path toward mentor program implementation (see Appendix H). In the mobilization phase, the completion of mentoring program articulation, including the change vision and monitoring and evaluation framework, are significant milestones and should be celebrated. In the acceleration phase, essential milestones include the culmination of mentor training and initial mentoring activities that deserve recognition from the participants and leaders. Finally, the major celebration will come as the program arrives at the end of its first cycle in the institutionalization phase. Program modifications are made for subsequent cycles and the scaling up of the mentoring program. This accomplishment should be widely communicated through all channels, with formal recognition to participants acknowledging the end of the formal mentoring program and encouraging readiness for the following change process.

Communication is often planned as an afterthought, despite its importance in contributing to successful change efforts (Beatty, 2015). This communication plan attempts to commit teachers to the change effort by making a case for change, addressing readiness, opening spaces for two-way communication, and influencing the frames for teachers to see the change by presenting time commitments and expectations. Lewis's model prioritizes teacher voice as a mechanism to adapt the program and shape it based on NCIS's teachers' cultural, linguistic, and philosophical context, shifting it away from traditional expert-driven STEM PD models. STEM coordinators and experienced teachers have the most credibility based on their role in supporting teachers. They can influence the frame by which experienced and new STEM teachers view the program. Measurement of communication tactics is collected through the message's reach and its impact. This data provides insight to answer evaluation questions on program effectiveness, as discussed in this chapter's monitoring and evaluation section. Finally, celebrations of milestones will maintain enthusiasm as the implementation moves through the four phases of the change path.

Chapter 3 Conclusion

This final chapter describes how the change will be implemented, how it will be evaluated, and how it will be communicated. Deszca, Ingols, and Cawsey's change path model, complemented by Duck's change curve, offers pathways to systematically implement a mentoring program that develops new STEM teacher skills and confidence. The monitoring and evaluation framework involves stakeholders developing evaluation questions, which serve as the foundations for data collection, analysis, and organizational learning. The communication plan also prioritizes stakeholder values and participation, leveraging two-way communication that amplifies teachers' voices.

Since STEM coordinators, mentors, and mentees are highly involved in this implementation; their contributions increase in future iterations of the mentor program. New STEM strategies, often originating from U.S.-based sources, must be mediated by NCIS mentors' and mentees' beliefs, backgrounds, experiences, and knowledge. This is so that STEM PD is more than just knowledge transfer; instead, it is contextualized learning in the NCIS environment, occurring in Spanish, English, or translanguaging, altering traditional patterns of postcolonial PD models at international schools. As STEM education moves geographically and conceptually away from its U.S. origins, educators enact it differently. Context matters, and so as educators implement STEM, school leaders must have the knowledge and courage to empower teachers, create interconnected professional growth opportunities, and break away from postcolonial patterns.

Next Steps and Future Considerations

This OIP has attempted to provide the support necessary to a group of passionate STEM educators at NCIS for their continued growth through professional mentorship. The hope is that through stakeholder involvement and distributed leadership, STEM coordinators and teachers will commit to future iterations of the mentoring program. Deszca, Ingols, and Cawsey's change path is cyclical. Ideally, mentees who complete the program will grow confident enough to participate as mentors in subsequent program iterations. Although too early to see evidence of this at NCIS, this involvement in professional growth and collective responsibility should translate to increased teacher tenure, the first line of inquiry for this OIP (Desroches, 2015; Mancuso et al., 2010). As the program grows in scale and complexity and more individuals are involved, it will be essential to stay true to stakeholder participation as both a means to strengthen the program and continually shift away from postcolonial patterns.

Continued Shift Away from Postcolonial Patterns

This OIP also attempts to catalyze a move away from the postcolonial patterns inherent in international education, this OIP's second line of inquiry. This will not be easy. As Tarc (2019) points out, the internationalization of education globally has brought with it an increase of pragmatic outcomes. The dualities framework, which illustrates tensions between pragmatic and idealistic discourses in international schools, maps out where the battle lines may be drawn between forces that accept postcolonial outcomes and those that aspire to a more global civil society vision.

STEM as currently enacted at NCIS spans both dualities; however, the solution strategies in this OIP will shift this program to the idealistic frame. Teachers' voices need to be recognized so that their cultures, beliefs, and prior experiences can mediate professional learning. A translanguaging environment optimizes learners' prior knowledge and background (Cenoz & Gorter, 2021) and promotes knowledge acquisition (Caldas, 2019; Garcia & Kleyn, 2016). It is hoped that the U.S.-based external sources of PD can continue to be mediated by local factors and efforts to provide PD in both languages. This would make STEM PD more relevant to NCIS teachers, breaking away from postcolonial patterns, and allowing the school to be part of the evolving landscape of STEM education.

STEM as an Evolving Landscape

STEM is enacted in different contexts worldwide, it takes on meanings that move away from the college- and career-readiness aims originally conceived by U.S. policymakers (Carter, 2017). STEM has evolved in some schools as a mechanism to close gender and minority gaps and overcome the underrepresentation of nondominant groups in STEM universities and the workforce (Celepcikay & Tarim, 2015). Viewing STEM through a cultural learning lens is an emerging area of STEM education research (see Garibay & Teasdale, 2019; Sahin, 2015). For example, Rahm's (2014) research explores how identity and valorization of different ways of knowing, doing, and being, mediate students' and teachers' engagement with STEM.

Students' backgrounds and cultures provide them with a rich STEM schema that can transfer to the classroom. Beyond encouraging the typical connections to STEM curricula, teachers must recognize the authentic patterns of STEM engagement practices present in students' lives outside school and how this can transfer to enthusiasm and engagement in academic STEM experiences. Teachers' pedagogical repertoires need to include the planning, assessment, and instruction of STEM experiences but also understanding how students' culture and identity mediate their engagement with STEM. This represents another horizon in STEM teacher instructional capacity, but one that has the potential to shift further away from postcolonial paradigms, create new understandings of STEM PD, and a more equitable and pluralistic view of education.

Narrative Epilogue

"Go with your passion." That was the advice I received from one of my course instructors—great advice for a doctorate and great advice for life. After almost three years of researching, thinking, discussing, and writing about STEM education, I am more passionate about it than ever. This journey has also offered some surprises. In the first iteration of my OIP, I contained the leadership ethics and equity topics to one section. However, once I decided to examine international school practices through a postcolonial lens, equity issues emerged in each dimension of this OIP. I was not expecting this, and I was certainly not expecting how this would challenge my assumptions as an international educator. I am humbled by the complexity of organizational change, readiness, and how teacher backgrounds, cultures, languages, and beliefs mediate their professional learning. As my scholarship meets my practice, I have more questions than answers. I have been fortunate to work and study alongside passionate, knowledgeable, and dedicated educators. I hope that my understanding will continue to mature as I gain experience in different international school settings and with people from different cultures.

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Appendix A

NCIS Classroom Observation Data

Learning environment	Pre-STEM implementation	Post-STEM implementation
Active learning	3.32[a]	3.39[b]
Digital learning	2.44[a]	2.44[b]

Note: Number of pre-STEM implementation observations carried out = 102, number of post-STEM implementation observations carried out = 48.

[a] Average score of total observations from September 2016 to October 2018. [b] Average score of total classroom observations from November 2018 to March 2020.

Appendix B

Cognia Staff Survey

Survey questions	2018 [a]	2019 [b]
In our school, a professional learning program is designed to build capacity among all professional and support staff members.	3.38	3.38
In our school, a formal process is in place to support new staff members in their professional practice.	3.55	3.54

Note: Average score of responses on a 5-point Likeart-type scale.

[a] Total response = 67. [b] Total response = 28.

Appendix C

PESTEL Analysis

Political	● The government is increasing the foundational skills of the workforce to take advantage of emerging technology (OECD, 2019). ● Government investment in free internet in rural and poor areas (OECD, 2020). ● Technology educational programs in schools and targeting skills development for industry 4.0 (OECD, 2019). ● The emergence of NGO REDCOLSI, an organization dedicated to incentivizing science and investigations in schools and universities (Konrad Lorenz University, n.d.). ● Ministry of Education launched the project STEM Route for 20,000 teachers to be certified as STEM teachers (Ministry of Education, 2020).
Economic	● The growth of the medical and petroleum industries in the local geographic area means more parents from STEM professions support this pedagogy (La Vanguardia Liberal, 2019). ● Latin American international school turnover rate of expat staff = 28% (Desroches, 2015). ● NGOs are investing in projects in the country, e.g.,) Siemens Siftung (2020).
Social	● COVID-19 and the increased workload and stress reported by teachers may be a factor in increased teacher turnover rates. ● A teacher well-being survey applied in May 2021 showed that 40% of staff reported signs of preclinical anxiety. ● The highest turnover rate at NCIS occurred in 2020 (38% of expat staff), possibly related to hardships brought on by teaching during a pandemic.
Technological	● Industrial revolution 4.0 means shifts in technology creating new industries and a need for an education that teaches skills for the industrial revolution 4.0. ● Availability of robotics, coding, Arduino, and 3D printing has increased, and costs have decreased, supporting design and engineering elements in STEM. ● Online learning at NCIS requires all students to purchase personal devices (laptops, iPads, etc.) to connect daily to classes.
Environmental	● Increasing alternative fuel sources impact the oil industry and major petroleum companies.
Legal	● The accreditation agency released certification for STEM schools/programs in 2015. ● Cognia accreditation and certification frameworks change on a 5-year cycle, requiring continued training on new protocols.

Appendix D

Comparison of Change Models

Change model	**Suitability for evolutionary change**	**Addresses learning**	**Leadership model alignment**
Lewin's stage theory of change (Hussain et al, 2018)	Unfreeze: as a result of crisis, does not differentiate revolutionary vs. evolutionary change	Change is linear: does not address learning	Poor alignment with transformational leadership
Deszca, Ingols, and Cawsey's change path model (2020)	Awakening: scan environment, external and internal forces	Capture what has been learned and document for future use (Institutionalization)	People are empowered during acceleration phase
Duck's change curve (2001)	Stagnation: does not differentiate revolutionary vs. evolutionary change	People's emotional maps and habits	Vision building with enthusiasm

Appendix E

Integration of Change Path and Change Curve

Integrated model	**Key elements**
Awakening–Stagnation	Create dissatisfaction, identify what needs to change, articulate a performance gap, gauge the change readiness of stakeholders to start building an appetite for change.
Mobilization–Preparation	Build support, develop a plan, communicate the reasons for the change, align plan with vision, generate energy and enthusiasm, manage resistance.
Acceleration–Implementation	Deploy change teams, implement, manage transitions, manage expectations, generate early wins, maintain focus, address beliefs and behaviors directly, reinforce desired actions.
Institutionalization–Determination–Fruition	Maintain enthusiasm, assess formal structures, manage conflict, leadership must stay involved, validate vision, address morale and motivation, celebrate gains, reflect and learn from the experience, leverage learning to build change capability for the future, prepare for next cycle.

Note: Adapted from Deszca, G., Ingols, C., & Cawsey, T. F. (2020). *Organizational change: An action-oriented toolkit* (4th ed.). Sage Publications.

Appendix F

Evaluation Questions

Evaluation question	Focus areas		Data collection tools	Responsibility
	Monitoring	Evaluation		
Appropriateness To what extent does the mentoring program recognize teacher beliefs, experiences, and attitudes?	Prevalence of gap in STEM PD, number of new STEM teachers	Description of PoP, mentor–mentee feedback	STEM PD surveys, classroom observations	Change leader
Effectiveness To what degree is the mentor and mentee adhering to the programmed activities?	Participation in training sessions, number of mentor–mentee interactions	Participant satisfaction, analysis of impediments to interaction between mentor and mentee	Surveys, structured interviews	Change leader, STEM coordinators
Effectiveness To what extent is the communication plan committing teacher to change effort?	Size of audience for program announcement	Number of participants resulting from announcement	Number of views on social media	Communication office
Efficiency Does the cost in time and money justify the delivered results?	Time required for implementation, cost of stipends	Cost benefit analysis of mentor program.	Mentor program expense report. Mentor program participation list and logs.	Change leader, STEM coordinators
Impact To what extent does the mentoring program increase collective capacity of STEM teachers?	Experimentation with new instructional strategies, STEM teacher perception of self-efficacy	Identification of additional benefits or negative effects.	Structured interviews	Change leaders, STEM coordinators
Sustainability Can the program be implemented on a larger scale?	Perception of program benefits, teacher capacity.	Program expansion, assessed learning of STEM pedagogy	Participant feedback surveys, structured interviews	Change leaders, STEM coordinators.

Note: Adapted from Markiewicz, A., & Patrick, I. (2016). *Developing monitoring and evaluation frameworks*. Sage Publications.

Appendix G

Monitoring and Evaluation Framework

Phase	Outcomes	Stakeholders	Actions
Context	Establish context, resource parameters, and approach to stakeholder participation.	STEM coordinators	• Create list of structures already in place that can be used for framework. • Decide scope of stakeholder participation.
Theory and logic	Establish theoretical approach and relation to program structure.	STEM coordinators	• Review assumptions on STEM education, professional learning with stakeholders. • Explore causal relationships in framework.
Evaluation Questions	Draft evaluation questions from 5 domains.	STEM Committee, STEM coordinators Mentors	• Review context, data, purpose, program theory, and logics • Draft evaluation questions for each domain.
Monitoring and evaluation plan	Determine evaluation methodology aligned with program theory and logics Determine roles, tools, and timeline to collect data to answer evaluation questions	STEM Committee, STEM coordinators Mentors	• Select methodology based on theoretical framework • Create list of contextual and individual factors • Create Gantt chart of data to be collected, tools, timeline, methodology, responsibility.
Data collection plan Data management plan Data synthesis, judgements, conclusions	Have a plan for data collection that is ethical, efficient, and is suitable for synthesis.	STEM committee STEM coordinators Mentors-mentees	• Assess data already in place for suitability • Identify additional tools for data collection (training, license purchase, etc.) • Identify ethical considerations in data collection
Learning approach, Reporting and dissemination	Sharing with broad audience	STEM coordinators Section principals Participant teachers STEM teachers Board of directors Senior leadership	• Capture reflections • Transform into lessons • Inform program redesign • Disseminate results

Note: Adapted from Markiewicz, A., & Patrick, I. (2016). *Developing monitoring and evaluation frameworks*. Sage Publications.

Appendix H

Change Path Milestones

Change path	Milestone	Stakeholders	Channels to communicate success
Awakening-Stagnation	Identify gaps Identify key stakeholders Gauge readiness Vision for change	Principals, STEM coordinators	Informal face-to-face
Mobilization-Preparation	Program outline Timeline Co-inquiry Mentor profile	STEM coordinators, select STEM teachers	Informal face-to-face
	Communicate change, program announcement/launch	Teachers, coordinators, principals, school community	Face-to-face, information sessions, formal memo, social media
Acceleration-Implementation	Mentor–mentee recruitment	STEM coordinators, mentor program participants	Informal face-to-face
	Completed mentor training	STEM coordinators, mentor program participants	Informal face-to-face
	First round (end of semester)	Principals, STEM coordinators, select STEM teachers, mentor program participants	Informal face-to-face
Institutionalization-Determination-Fruition	Completion first cycle (end of school year)	Principals, STEM coordinators, select STEM teachers, mentor program participants	Informal face-to-face
	Revisions to policy completed	STEM coordinators, select STEM teachers	Informal face-to-face
	Mentor program announcement (cycle 2)	Teachers, coordinators, principals, school community	Face-to-face, formal memo, social media, graduation ceremony

Note: Adapted from Deszca, G., Ingols, C., & Cawsey, T. F. (2020). *Organizational change: An action-oriented toolkit* (4th ed.). Sage Publications.