

*Project InTERSECT: Inquiry to Transform Educator Readiness for
STEM+C Early Childhood Teaching*

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Project InTERSECT

The notion of an early childhood STEM+C classroom brings to mind a vision of young students in small groups, engaged in playful *standards-driven exploration* with a variety of manipulative materials, robots, building blocks and other tech toys. The young learners, informally stationed around the room, are carefully *investigating* the process needed for building a new home for a story character. Some are building *content knowledge* through direct teacher instruction on measurement standards. Others are engaged in *creating* a vehicle that can move their building materials to the *imaginative* construction site. Others are *testing* their structures by *collecting* and *analyzing data*. Some are exploring books in the literacy area on the subject related to the work the vehicle perform, while others are writing a sequel to the original story using the new home they have created. As they apply an increasingly varied range of student-led learning, they develop self-regulation, persistence, and collaboration through lively discussion with classmates.

Consider the teacher working to support student learning in this learning environment. What skills, knowledge, and dispositions does this teacher need to scaffold student learning, redirect misconceptions in math and science, and lay the foundation for critical computational thinking skills that young children will need to successfully move from early childhood learning into the challenging content needed to innovate and solve the problems they will face as adults? From a glance, the presence of the STEM+C learning tools gives an indicator that the learning will match the goals articulated for these young students to collaboratively explore, learn, and build their knowledge. But there is a problem. Most teachers in classrooms today are not equipped to teach in this learning environment. Deficits in teacher content knowledge (CK) in math and science persist, and few teachers have adequate exposure to computational thinking. The effect of these deficits is too often reflected in student achievement, especially in the most

challenged and underserved communities. Envision this class with a teacher who is a leader in STEM+C education, accomplished in both CK and pedagogy, ready to facilitate in this rich learning environment. This is the vision to be brought to life through **Project InTERSECT**.

The College of Education and Human Services (COEHS) at the University of North Florida (UNF) will expand existing partnerships with Duval County Public Schools (DCPS) and Northeast Florida Regional STEM2Hub to address **Absolute Priority 1: Supporting Effective Teachers**, focusing on providing teachers with (1) Evidence-Based Professional Development (PD) activities that address the needs of DCPS students; and (2) Evidence-Based professional enhancement activities, including activities leading to an advanced credential.

Project InTERSECT is an entirely online set of professional learning and enhancement experiences for pre-kindergarten through second grade (PK-2) teachers and teacher candidates. Designed to transform educator readiness and capacity to engage in STEM+C instruction, the project will strengthen content (CK) and pedagogical content knowledge (PCK; Shulman, 1986) in mathematics, science, and computer science, which are often areas of weakness for primary teachers (Nadelson et al., 2013). Using inquiry as a teacher learning tool, the project will support early childhood educators in building intersecting CK, finding the pedagogical intersections of STEM+C instruction, and using problem- and project-based learning (PBL) to integrate STEM+C instruction within their classrooms. Project InTERSECT recognizes that strong instructional practices emerge at the intersection of content, pedagogy and implementation.

The project is built on **evidence-based approaches** for improving students' mathematics and science achievement including studies that meet What Works Clearinghouse (WWC) standards with (**Moderate Evidence**) and without reservations (**Strong Evidence**) which highlight the efficacy of inquiry (Heller, Daehler, Wong, Shinohara, & Miratrix, 2012) and

learning trajectories for young learners (Sarama, Clements, Wolfe, & Spitler, 2012). Through this confluence of deep CK and inquiry with developmentally appropriate practices (DAP), the project is designed to enhance young learners' achievement in STEM, computer science, and computational thinking (**CPP1-Promoting STEM Education, with a Focus on Computer Science**), while concurrently fostering self-regulation skills in PK-2 students (**CPP2-Preparing Students to Be Informed, Thoughtful, and Productive Individuals**).

Across **three cohorts**, the project will serve 180 teachers and teacher candidates with direct and immediate impacts on the instruction of over 3,000 PK-2 students across a pool of 74 high-need DCPS elementary schools, including six Charters, two DCPS-UNF Professional Development Schools, and the UNF preschool, with prioritized implementation in 17 schools in **Qualified Opportunity Zones (CPP3-Spurring Investment in QOZs**; see Appendix G). The project employs a cluster-level Quasi-Experimental Design with business-as-usual comparison group ($n = 270$) to assess the effectiveness of project activities in improving student and teacher outcomes. **The study is designed to meet WWC Standards with Reservations.**

A. Quality of the Project Design

A1. Exceptional approach to the priorities. Project InTERSECT is an exceptional approach to supporting and developing teachers in high-need schools. Built on evidence-based approaches, the project incorporates: (1) **intersection of academic and social emotional learning (SEL)**, building teacher CK and PCK to improve young learners' achievement and interest in STEM+C; (2) **self-directed, collaborative inquiry**, providing teachers and candidates with individually-driven online learning experiences strengthened through multiple sources of virtual collaboration; and (3) **stackable credentialing**, providing teachers and candidates with professional enhancement and credentialing opportunities along personalized, parallel pathways.

Intersecting Academic and SEL. Project InTERSECT is designed to strengthen PK-2 teachers' CK and PCK of STEM and Computer Science (**CPP1**), with a concurrent focus on developing student self-regulation (**CPP2**) through integrated, developmentally appropriate problem- and project-based learning (PBL). Problem-solving in STEM+C requires young children to draw on self-regulatory skills to plan, choose effective strategies, monitor and control emotions, and evaluate their progress toward a goal (Whitebread et al., 2009). Fostering self-regulation is critical to **long-term academic and social-emotional development**, and trajectories for success in other life domains. Development of self-regulation skills has lasting positive impacts on students' social competence, mental health, and factors associated with increased physical wellbeing (Robson, Allen, & Howard, 2020). Building young children's self-regulation requires tasks that are developmentally appropriate, meaningful to the child, and sensitive to working memory capacity (Whitebread et al., 2009). Thus, as part of the PCK of teaching STEM+C, teachers must develop their knowledge of students' self-regulation capabilities to provide scaffolds for task choice, control over the level of challenge, and opportunities for self and peer evaluation (Perry et al., 2002; DeCorte et al., 2000).

However, many early childhood teachers teach STEM disciplines in the same ways they were taught (Nadelson, 2013). This most often involves: (1) a reliance on direct instruction, and (2) a procedures-only (i.e., procedures without concepts) focus. Such practices are especially problematic in mathematics lessons (e.g., addition, subtraction, and multiplication lessons in PK-2 standards) and ensuing STEM+C lessons relying on mathematical background knowledge. These instructional challenges impact STEM+C achievement and social-emotional development, particularly for high-need students, by neglecting to (a) make important connections across disciplines and (b) promote students' use of critical problem-solving and self-regulation skills.

Project InTERSECT will support teachers in using kid-friendly, contextually relevant problem-solving activities requiring mathematical and scientific reasoning, engineering task design understandings, and computational thinking strategies. Participants will learn to use models, manipulatives, and simulations to blend STEM+C content and *blur instructional lines* that often isolate the disciplines into separately taught subjects. Using the STEM+C practice standards (Appendix I) as a guiding framework, teachers will learn to *design and implement developmentally appropriate PBL* curricula to support students in solving problems and creating strong rationales for defending solutions, thereby fostering critical self-regulation skills that prepare students to be informed, thoughtful, and productive individuals.

Self-directed, collaborative inquiry. Research has established strong links between self-directed, practice-connected, collaborative PD, enhanced instructional practice, and student learning (Garet et al., 2001; Desimone, 2009; Lopes & Cunha, 2017; Levine & Marcus, 2010). Transformative Learning theories highlight the importance of an individual's personal accountability and self-monitored control over the learning process. Adult learners, in particular, have an underlying need for self-directed, experiential learning. They become accountable for the learning process when the learning is personally relevant and individually-driven, and when they have opportunities to interact with the learning experience and share ideas and practices with others (Mezirow, 1985; Knowles et al., 2005; Baumgartner, 2001; Carpenter, 2015).

Providing teachers with meaningful, collaborative learning experiences that are directly tied to the work they do in their classrooms (DeMonte, 2017) increases motivation and goal commitment (Vescio, Ross, & Adams 2008; Locke & Latham, 2002) and enhances teacher efficacy, which has been empirically linked to teacher practice and student performance (Hattie, 2009; Voelkel & Chrispeels, 2017; Donahoo, 2017). When focused intently on student learning,

such collaborative, practice-connected processes can lead to improved academic outcomes over time (Vescio et al., 2008; Darling-Hammond & McLaughlin, 1995; Lieberman & Miller, 2014).

Practitioner inquiry (also referred to as practitioner research, teacher research, or teacher inquiry) is inherently self-directed, collaborative, and practice-connected. Inquiry provides teachers with meaningful understandings of their own practice, allowing them to appropriately respond to students' learning needs, by making 'problematic their own knowledge and practice as well as the knowledge and practice of others' (Cochran-Smith & Lytle 1999, p. 273) through systematic and intentional study of their classroom practice (Dana et al., 2017).

Collaborative inquiry has demonstrated efficacy as a teacher professional learning tool. Research suggests that inquiry improves practice (Dana et al., 2017; Slavit & Nelson, 2010) as it promotes deep reflection (Levin & Rock, 2003), fosters shifts in teachers' beliefs about instruction (Dawson & Dana, 2007; Hagevik et al., 2012), and enhances teachers' understanding of and ability to adapt instruction to individual student needs (Dresser, 2007; Wallace, 2013; Rinke & Stebick, 2013; Butler & Schnellert, 2012; Hyland & Noffke, 2005; Martin, 2005).

Drawing on this plethora of research, InTERSECT engages participants in collaborative inquiry, designed to support teachers as they define and study problems of practice associated with implementing STEM+C (using student work and other classroom data) within their classrooms and schools. The project is unique in its explicit incorporation of collaboration across multiple sources. Specifically, the program's deep focus on STEM+C CK and PCK will be supported through content segments coupled with: Virtual Coaching Cycles; Virtual Professional Learning Communities; and Virtual Mentoring, which pairs each teacher candidate participant with a participating in-service teacher leader. This multi-source approach builds a *community of practice*, connecting participants with peers as they reflect on STEM+C content, examine student

and classroom data, and plan integrated curriculum and instruction.

Stackable credentialing along personalized, parallel pathways. We define stackable credentials as a system of linked PD badging, graduate certificates, and graduate degrees that encourage teachers to continue or stack their learning. Stackable credentials offer considerable promise as they allow a teacher to acquire a credential in less time than it would take to earn a full degree typically resulting in higher completion rates (Baily & Belfield, 2017). When the short term credential serves as part of a sequence of credentials that efficiently lead to a degree, then this “stackable credential” leaves open the option for a student to acquire a degree later. These experiences build on and parallel one another.

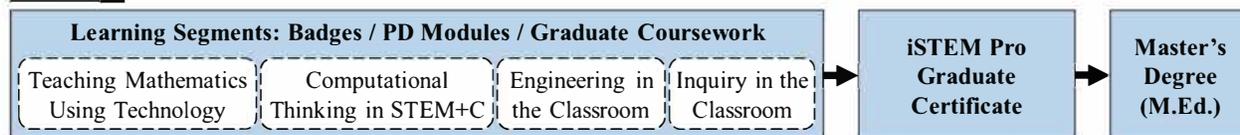
Research highlights several important points regarding the efficacy of this approach. First, a stackable approach provides a mechanism whereby participants have the opportunity to develop smaller chunks of knowledge *and* experience success along the way. This is particularly important in light of research that suggests many PK-2 teachers demonstrate low self-efficacy and confidence in STEM areas (Brand & Wilkins, 2007; Munck, 2007). Thus, stackable credentialing shows promise to offer introductory doses of STEM PD without intimidating early childhood educators who may be apprehensive about math and science instruction.

Second, stackable credentialing increases accessibility of learning, utilizing chunking to break down complex instructional skills into fundamental parts. Researchers have suggested that such chunking can enable educators to develop mastery in complex skills by weaving together bite-sized elements of instruction (DeMonte, 2017). Stacking provides quality support along the way, with the end goal of building complex pedagogical content knowledge over time. Finally, stackable credentials provide teachers with valuable skills that have the potential to be embedded in higher-level certification and advanced degrees (Bailey & Belfield, 2017). In this way, a

stackable approach can develop a pipeline for teacher leadership.

Project InTERSECT’s systematic approach to teacher credentialing provides a choice of foundational, moderate, or deep learning opportunities designed to provide flexibility and a personalized approach to teacher enhancement. Specifically, along three pathways (described in detail in Section A2 and Appendix I), participants can earn graduate course credit, District PD credit, or micro-credential badges. Learning segments can be stacked toward a certification, which can then be embedded into a Master of Education (M.Ed.) degree. This stackable approach will encourage participants to *develop professional competencies* and intentionally professionalize their practice and create a *cadre of STEM+C teacher leaders* who are prepared to facilitate change within their classrooms and schools. The approach is overviewed in Figure 1.

Figure 1. Overview of Stackable Credentials



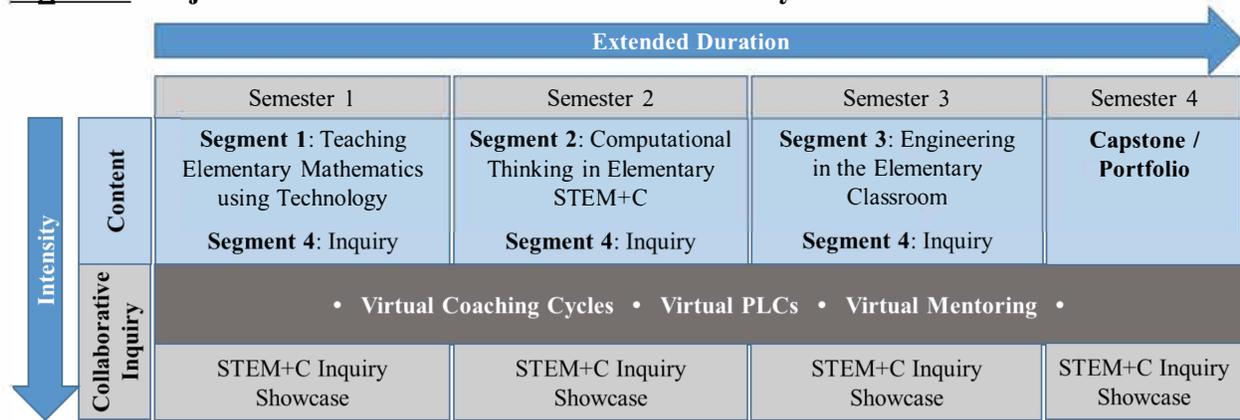
A2. PD quality, intensity, and duration. The project design seamlessly integrates attention to quality, intensity, and duration. The quality of the PD is evident in its focus on increasing teachers’ knowledge of STEM+C subject matter content and how students learn that content, with a simultaneous emphasis on delivering content in alignment with appropriate standards (Desimone, 2009). Quality is also apparent in our commitment to collective participation by intentionally grouping teachers in PLCs to structure long-term and developmentally-sensitive interaction and discourse. Intensity of the PD relies on high levels of interaction and self-directed learning, challenge associated with the content or new material, high expectations established for evaluation, and the expectation to transfer new knowledge to practice. Finally, by systematically linking chunks of knowledge across time, a duration of professional learning, well beyond the recommended 20 hours of minimum contact time, is established to assure intellectual and

pedagogical change (Cohen & Hill, 2001; Desimone, 2009; Supovitz & Turner, 2000).

InTERSECT pairs uniquely configured STEM+C content with teacher collaborative inquiry, linking newly developed professional knowledge to classroom practice. Content consists of four systematically scaffolded segments completed over 3 semesters: **Segment 1:** Teaching Mathematics using Technology; **Segment 2:** Computational Thinking in STEM+C; **Segment 3:** Engineering in Elementary Classrooms; **Segment 4:** Collaborative Inquiry in PK-2 Contexts.

Segments 1-3 (one per semester) are completed sequentially, with segment 4 integrated into each semester. Promotion of SEL and self-regulation through PBL is embedded within each segment. The content for each segment which integrates new and existing coursework with module-based competency badges and open access resources (Appendix I) will be reinforced through a set of supporting **collaborative inquiry experiences**. The sequence (duration) of STEM+C learning and coupling of supporting experiences (intensity) are presented in Figure 2.

Figure 2. Project InTERSECT PD Duration and Intensity

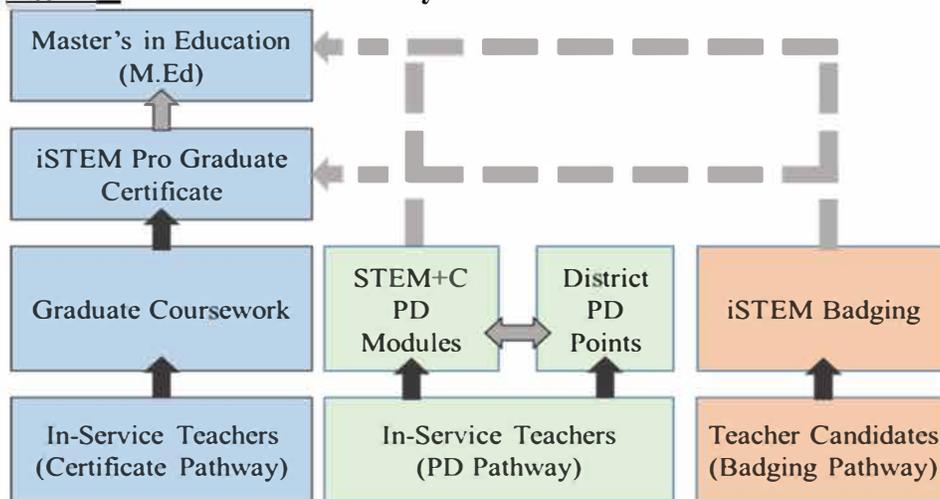


Collaborative inquiry relies on the continual collection and use of data to examine and address student learning needs. The inquiry cycle begins with a data-driven planning and implementation component each semester, supported by: (a) virtual PLCs; (b) virtual layered coaching; and (c) virtual mentoring. Additionally, each semester a virtual inquiry showcase will connect all participants to share their work and lessons learned. In the final semester, participants will

complete an electronic portfolio documenting program artifacts (e.g., lesson plans, lesson video, student work). Program components are discussed in detail below.

Personalized Learning Pathways. In order to tailor this learning opportunity to individual needs, participants will choose a personalized pathway, distinguished by the depth of content (see descriptions of content and activities in Appendix I). These pathways are illustrated in Figure 3.

Figure 3. Personalized Pathways and Stackable Credentials



In-service teachers may choose from two pathways: Graduate Certificate or PD Modules. The **iSTEM Pro Graduate Certificate** cultivates STEM+C Teacher Leaders by providing a deep dive into of each of the four segments through graduate-level coursework. This pathway pairs comprehensive knowledge of each segment with a deep focus on the intersections of content, pedagogy, and implementation. Teachers who complete project coursework (along with two additional courses- Appx I) will earn the graduate certificate. The certificate can be embedded into an M.Ed. degree, which will position completers with the knowledge and skills needed to serve as teacher leaders prepared to support the learning of other professionals. The project will provide **over 240 hours of support** to 15 teachers per cohort (45 total) on this pathway.

The **iSTEM PD Module** option provides in-service teachers with PD in each of the four segments without the depth of content or leadership development activities associated with the

certificate pathway. Delivered through online modules, the PD will provide a moderate dive into STEM+C instruction. As shown in Figure 3, PD modules can be converted into district PD credit (which is state-mandated for recertification of teaching credentials). Participants may also submit PD credit for review, and, if approved, apply the PD toward graduate certificate course tasks (in Fig. 3, this optional path is represented by gray dashes). The project will provide **120 hours of support** to the 30 teachers per cohort (90 total) on this pathway.

iSTEM Badging for teacher candidates (15 per cohort; 45 total) is designed to provide a foundational dive into of each of the four segments, providing an estimated **60 hours of support** to each participant. Candidates who complete the badges and a mentored capstone experience will receive a cord signifying completion at graduation, and will be positioned to enter the PK-2 Classroom with foundational expertise in STEM+C. Post-graduation, if they choose to pursue a graduate certificate or M.Ed., they may submit artifacts from their badge work for review as evidence of task completion (dashed pathway in Fig. 3).

Collaborative Inquiry. Across all learning pathways, content will be intentionally coupled with collaborative inquiry as a mechanism for supporting the teachers' integration of deep CK, engaging instruction, and standards-based curricula to create STEM+C PCK that results in rich integrated STEM+C PBL within their classrooms. Our approach builds on the inquiry model developed by researchers at the University of Florida (Prime Online- see B1). The design intersects: (1) Garrison's (2013) online community of inquiry framework; (2) inquiry work that emphasizes a systematic and intentional approach to teachers studying their practice (Dana & Yendol-Hoppey, 2019) within the K-12 classroom context (Cochran-Smith & Lytle, 2001, 2009); (3) Desimone's (2009) PD design characteristics; and (4) Wenger's community of practice work (1999). Collaborative inquiry tools are summarized in Figure 4 and detailed below.

Figure 4. InTERSECT Collaborative Inquiry



Inquiry will be embedded within each content segment using *teaching cases* to examine and plan for student needs and engage participants in *Approximations of Practice* and *Decomposition of Practice* (Grossman, Hammerness, & McDonald, 2009). *Virtual Professional Learning Communities (VPLCs)* will provide peer support to help participants explicitly plan how to implement new STEM+C

knowledge and skills based on student needs within their specific teaching context. In-service teachers will be grouped into vertical teams (e.g., membership across PK-2) to engage in *lesson study* (Fujii, 2019; Lewis & Hurd, 2011) and *looking at student work* protocols (Gearhart et al, 2006; Heller et al 2012; Kazemi & Franke, 2004; Little et al, 2003), allowing teachers to support one another in developing school- and classroom-specific interpretations of STEM+C implementation (Horn & Kane, 2019; Horn, Kane, & Wilson, 2015). Participants on the PD and badging pathways will also participate in VPLCs with the teacher leaders enrolled in the graduate certificate where they will receive peer coaching support. The VPLC norms will be tough on practices, not people, focus on student thinking, and encourage self-reflection (MacDonald, 2011; Goodwin & Hein, 2016).

Virtual Layered Coaching (VLC) will include content coaching, peer coaching, and inquiry-based instructional coaching using a layered approach. Our VLC model will adapt the University of Florida Lastinger Center’s Early Learning Coaching Model, which was co-

developed by UNF's Dr. Jamey Burns and adopted by Florida's Office of Early Learning, to create a STEM+C Standardized Instructional Data-driven Coaching (SIDC) model. SIDC is built on adult learning principles (Blanchard et al., 2011; Knowles et al., 2005) and key components of early childhood education coaching (O'Keefe, 2017). Research has found that, when coupled with early childhood courses, the model significantly improved teacher knowledge, instructional practices, and young children's ongoing development and learning (Rodgers et al, 2017).

Our adapted model will provide participants in all pathways job-embedded VLC as they integrate STEM+C instruction in their classrooms. Each semester, VLC will follow a modified SIDC cycle (Appendix I). Using data to examine student needs, VLC will include planning, video observation, and examination of student work. During the final semester, the participants will work with their coaches on a capstone inquiry focused on integrating project- and problem-based STEM+C instruction within their PK-2 classroom. The coaching cycle will support implementation and help navigate school schedules and curriculum structures to ensure practices are integrated and sustained. Coaches and teachers will document instruction and coaching conversations with videos. Videos and other artifacts (e.g., student outcome data) will be used as part of the teachers' portfolios and may be included in the video/lesson bank (described below).

Teacher candidates will complete 8 hours of mentored STEM instructional time within the UNF Solve, Tinker, Explore, Play (STEP) Lab, in an afterschool program at a DCPS-UNF Professional Development School, within a mentor's classroom, and/or at the UNF Preschool. In addition to the support they receive within those contexts, candidates will receive ***virtual mentoring*** from an InTERSECT teacher. These teacher/teacher candidate dyads will collaborate on planning for implementation and examining student work. The benefits of this approach are twofold, supporting teacher candidates as they make sense of their STEM+C teaching, while

concurrently developing teacher leadership skills of the mentoring teacher. Building this capacity facilitates sustainability as it develops teacher leaders prepared to assume a key role in preparing the next generation of school-based teacher educators (Yendol-Hoppey, Dana, & Hoppey, 2019).

Each semester, a *Virtual Inquiry Showcase* will provide teachers the opportunity to present their collaborative inquiry work highlighting examples of successful STEM+C implementation, which will be facilitated through UNF’s Telepresence Lab. Participant *electronic portfolios* will consist of (1) video clips, (2) data-displays of classroom observations, (3) student work/reflections on student work, and (4) coaching conversations. Feedback will be provided by content, inquiry and peer coaches. Lesson plans and accompanied video illustrations that demonstrate high levels of STEM+C instruction will be selected for inclusion in a *video and lesson plan bank*, available on a UNF Digital Commons Site, creating free access to other early childhood educators and educational leaders interested in integrated PK-2 STEM+C instruction.

In summary, InTERSECT provides a fully online approach to supporting teacher and candidate learning that combines a deep focus on STEM+C content and pedagogy along personalized pathways. Learning segments are coupled with collaborative inquiry activities (Fig. 4) designed to deepen learning, support implementation, and sustain support beyond the duration of the grant. Table 1 shows the implementation timeline.

Table 1. Implementation Timeline

Cohort	Y1: 2020-21			Y2: 2021-22			Y3: 2022-23		
	Fall	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum
Coh. 1	Development/ Baseline Data		Segment 1 & 4	Segment 2 & 4	Segment 3 & 4	Capstone Portfolio	Outcome data collection		
Coh.n2	Development/ Baseline Data			Segment 1 & 4	Segment 2 & 4	Segment 3 & 4	Capstone Portfolio	Outcome data	
Coh. 3	Development/ Baseline Data					Segment 1 & 4	Segment 2 & 4	Segment 3 & 4	Capstone Portfolio

A3. Project addresses the needs of the target population. DCPS, a high-need urban school district, employs more than 7,500 teachers serving over 130,000 students in 172 public schools, including 26 charters. It is the 7th largest LEA in Florida and the 22nd largest in the US. Project InTERSECT will serve teachers in **74 of DCPS’ highest-need elementary schools**, with prioritized recruitment and implementation in 17 schools in **Qualified Opportunity Zones** (QOZs). We will address the needs of these teachers and their students in the following ways.

Providing underrepresented students with access to STEM+C learning. Across Duval County, 21 percent of families with children are below the poverty line and 33 percent of adults over 25 have less than a high school degree (US Census, 2017). InTERSECT serves high-need, underrepresented students (95% economically disadvantaged and 78% non-white). These students underperform their state- and district-wide counterparts in Math, Science, and English Language Arts, with students in QOZs exhibiting the largest gaps (Table 2).

Table 2. Student Achievement and Demographics

Student Population	% Ready for Kindergarten	% on grade level- K-2*		% Proficient-Gr. 3-5		
		ELA	Math	ELA	Math	Science
Florida Elementary-all	53%	--	--	57%	63%	53%
DCPS Elementary-all	51%	70%	70%	53%	62%	51%
DCPS Priority Elem.	41%	61%	57%	38%	52%	38%
DCPS QOZ Elem.	39%	55%	50%	34%	45%	27%

**Note:* State assessment data for grades K-2 are not uniformly available, so are not reported here.

As shown, these gaps exist early (with low kindergarten readiness) and persist through elementary school grades. Gaps may be explained by three confounding factors: (a) limited access to STEM+C in *early grades* (formal computer science education, for example, begins in Grade 4); (b) limited access to *integrated* STEM+C instruction (i.e., STEM+C is often taught as separate, non-overlapping subjects); and (c) limited access to *developmentally appropriate* STEM+C learning opportunities (i.e., many PK-2 teachers tend to rely on direct, procedures-only

instruction in these content areas). Project InTERSECT provides PK-2 students from underrepresented groups and under-resourced schools **access to integrated, developmentally appropriate** STEM+C learning opportunities. This is particularly important considering the prominent racial, economic, and gender disparities in STEM+C fields (Chubin & DePass, 2014). Project InTERSECT aims to remove such barriers by incorporating **evidence-based methods** with demonstrated efficacy for student populations similar to those targeted by this project. For example, Wolfgang, Stannard, and Jones (2006) found that using manipulatives (i.e., LEGOs) in early grades has long-term impacts on student mathematics achievement, with significant effects evident in middle and high school. In another study (see Section B1), Sarama et al. (2012) found that using developmentally appropriate instructional models and manipulatives, as is proposed in our study, was especially effective for children who identified as African American. Across DCPS, 41 percent of PK-2 students are African American, underscoring the importance of providing instructional strategies specifically designed to meet these students' needs.

Providing PK-2 teachers with access to quality personalized PD. The efficacy of personalized, evidence-based PD and meaningful peer collaboration is well-established. However, teachers face significant barriers associated with the time and cost of PD and peer collaboration, and have long-expressed disinterest in “one-shot” workshops (which researchers have also indicated as ineffective; e.g., Dana et al., 2017). One-shot, face-to-face PD, however, remains a prominent approach in many school districts, and ongoing, job-embedded, collaborative PD, including PLCS, is frequently implemented without fidelity which inadvertently exacerbates drains on time and motivation. InTERSECT is designed to address these challenges, implementing virtual, personalized, collaborative learning. Teachers have expressed interest in using technology in PD (Demonte, 2017), emphasizing the importance of

the flexibility it gives them to create their own schedule for engaging in professional learning (Will, 2017). The project will provide virtual opportunities that address **individual teacher needs**, are **tailored to their busy schedules**, the ability to easily **integrate quality resources** and expertise (Dede et al. 2009), and offer **job-embedded support** (Whitehouse et al., 2006).

Increasing PK-2 teachers' STEM+C confidence and self-efficacy. Many PK-2 teachers have “constrained background knowledge, confidence, and efficacy for teaching STEM that may hamper student STEM learning” (Nadelson, 2013, pg. 157). The critical teacher shortage in large urban districts and the high percentage of novice and alternatively certified teachers in the project schools (i.e., more than half of the teachers in QOZs have fewer than 4 years' experience in the field) exacerbates issues of low teacher efficacy in STEM+C areas, particularly among PK-2 teachers (Brand & Wilkins, 2007; Munck, 2007). As high stakes accountability shifted instruction to more teacher driven instruction over two decades ago, many teachers who now teach in target schools never experienced PBL or deep engagement with critical thinking as young learners, leading to the problem, “You can't teach what you don't know.” Systemic barriers to teachers' development of confidence and efficacy in STEM+C also exist. For example, in Florida, Computer Science (CS) standards reside within science standards, adding to the difficulties faced in unpacking standards, particularly for novice teachers. Additionally, CS certification requirements for elementary teachers are identical to those for secondary teachers (Florida CS certification is K-12). As of the 2019-20 school year, only 8 teachers throughout DCPS schools are certified in CS and none of those teach at the elementary level. InTERSECT will strengthen participants' CK and PCK across STEM+C domains, support implementation in their classrooms, and offer personalized pathways to develop STEM+C instructional expertise, **improving the confidence and efficacy of both veteran and novice teachers.**

A4. Incorporation of project purposes, activities, benefits into ongoing work. Beyond grant funding, the project will be sustained within DCPS and likely expanded to include other districts across the state of Florida. Sustainability is highly likely due to 4 key strategies, described below.

(1) The project capitalizes on existing relationships, structures, and networks. The project is supported by its partners, DCPS and STEM2Hub, and many large non-profit organizations in northeast Florida responsible for enhancing PK-2 learning and ensuring equitable access to STEM preparation (see Letters of Support-Appx D). These organizations include Kid’s Hope Alliance, Florida Institute for Education, Jacksonville Public Education Fund, and the Early Learning Coalition. Their collective voices, in combination with goals of the Jacksonville Chamber of Commerce to develop a robust STEM career pipeline, assures that InTERSECT expertise will be recognized, shared, resourced, and disseminated widely. Strong relationships between STEM2Hub (directed by InTERSECT Co-PI Kathleen Schofield) and organizations including Microsoft, LEGO Education, Florida Department of Education, MIT, and the Samueli Foundation provide important opportunities for future funding and dissemination to ensure sustainability of this work. Additionally, the DCPS-UNF Professional Development School (PDS) network structure and our UNF Preschool’s role in demonstrating “research in action” has existed for over two decades, resulting in strong relationships between the district and university. PDS will serve as ongoing demonstration sites for strong PK-2 STEM+C instruction. Project InTERSECT is also networked with other units on campus including the College of Computing, Construction, and Engineering and the College of Arts and Sciences. These units collaborate with the UNF COEHS to offer STEM+C PD to middle and high school teachers. As a result, InTERSECT teachers are critical to developing a pipeline of PK-12 students. Finally, UNF has a close relationship with the Northeast Florida Educational Consortium who are interested in

building PK-2 Teacher STEM+C capacity in the rural districts they serve. In sum, *relationships, structures, and networks* position the work to be shared and modeled long after the grant ends.

(2) The project develops teacher leadership capacity needed to provide affordable STEM+C content and coaching for additional PK-2 teacher cohorts engaged in collaborative inquiry once the grant ends. Given that PK-2 STEM+C is an emerging field, cultivating human capacity to teach and lead in this area is key to sustainability. Project InTERSECT builds teacher leadership capacity within the participating schools and district through the graduate work and PD modules. Once the initial investment in developing teacher leadership capacity is made, schools are positioned to use the newly minted teacher leader talent. These teacher leaders will also have access to the high quality collaborative inquiry protocols created through the project to facilitate collaborative learning. Thus, the financial resources needed to offer additional teachers PD decreases substantially. Additionally, beyond the term of SEED funding, the project will continue to build a broad base of public and private support (including above-mentioned partners), generating additional revenues based on our demonstrated ability to develop and deploy teacher leaders capable of improving the teaching of STEM+C across content areas.

(3) The project supports the integration of PK-2 STEM+C teaching and learning across the curriculum and provides a bank of tested and vetted resources to support integration.

Important to sustainability of innovative instruction is the teacher's ability to integrate new content into existing instructional expectations. This is particularly difficult in contexts which have felt the pressure of high stakes testing resulting in highly scripted instruction. As a result, InTERSECT's approach is to provide high levels of support to teachers as they learn to integrate PK-2 STEM+C instruction into mathematics, science, and literacy. Integration requires a higher level of teacher expertise that will be supported through collaborative inquiry. Once examples of

integration are captured, modeled, and shared, infusion of STEM+C instruction across the curriculum will emerge as teachers build opportunities for problem- and project-based learning. An outcome of the teacher leader work will be a bank of video lessons coupled with lesson plans and evidence of student learning to support integrated PK-2 STEM+C teaching and learning.

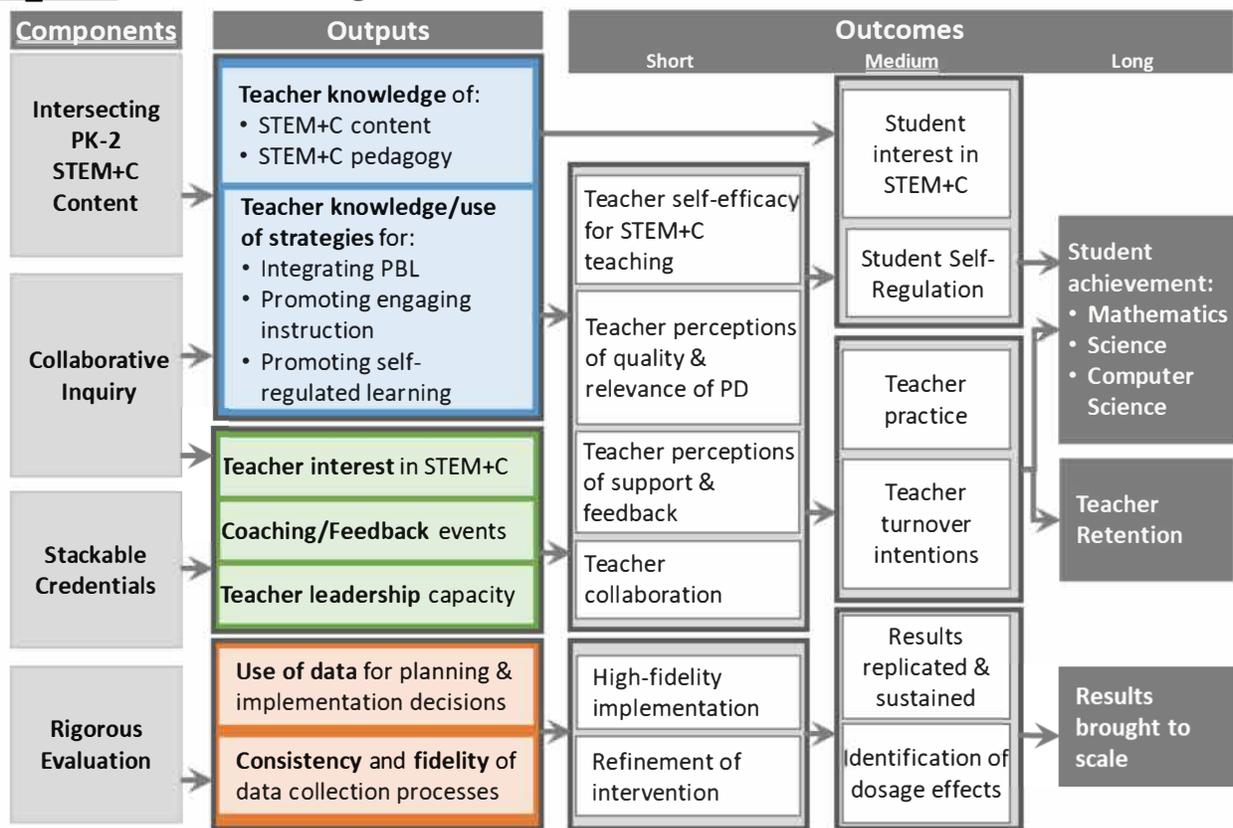
(4) The college will integrate credentials within programs and extend scholarship dollars to those InTERSECT Graduate Certificate awardees to support completion of the M.Ed. Even after the completion of the grant, the UNF COEHS will continue providing co-curricular and curricular PK-2 STEM+C components for teachers interested in teacher leadership and candidates interested in a credential that demonstrates unique expertise in PK-2 STEM+C. The Badging developed for candidates will be formalized with the graduation cord and opportunities to connect to UNF-recognized undergraduate research and community service. Competitive scholarship support, coupled with opportunities to serve as school-based teacher educators/mentors to our teacher candidates will be offered to Project InTERSECT Graduate Certificate awardees. These efforts will support completion of the M.Ed. Additionally, the 1-credit Collaborative Inquiry Course will be marketed to districts as a cost effective support for coupling the learning of important new content and pedagogy with collaborative inquiry opportunities.

B. Significance.

B1. Magnitude of the results. The InTERSECT Logic Model (Figure 5; expanded in Appx. H) presents relationships between the intervention's critical processes, outputs, and outcomes. As shown, intersecting STEM+C content (i.e., content that integrates CK and PCK across STEM+C domains and embeds SEL through PBL), Collaborative Inquiry (as the mechanism for supporting intersecting content using the inquiry tools described in A2), and personalized, stackable credentialing paths work together to produce changes in teacher knowledge and use of strategies

and build programmatic and human capital capacity. These outputs impact teacher perceptions, including self-efficacy, collaboration, and perceptions of support, which in turn lead to improved teacher practice and, ultimately, student achievement. Detailed paths, indicated by arrows, are aligned with the research model (section D) which hypothesizes the mediating effects of short- and medium-term outcomes on achievement. The model also highlights the role of research evaluation in identifying implementation strategies for sustaining/replicating results.

Figure 5. InTERSECT Logic Model



Likelihood of Achieving Intended Outcomes. Our outcomes are expected to be strong, as the design principles reflect overlap with those that led to significant impacts on student achievement and teacher practice in several previous studies. First, InTERSECT utilizes two effective models identified by Heller et al. (2012). A randomized controlled trial (RCT) meeting **WWC standards without reservations (Strong Evidence)** examined the use of inquiry for

developing PCK in urban Grade 4 teachers. They found that, when coupled with strong content instruction, *Teaching Cases* and *Looking at Student Work* each had significant impacts on students' science achievement and resulted in heightened conceptual understanding for both teachers and students. InTERSECT integrates the pedagogy of *Teaching Cases* into the content of each PD segment through in-class coaching. This provides participants the ability to engage in approximations of practice and decomposition of practice (Grossman, Hammerness, & McDonald, 2009) scaffolded by the course instructor. Our design then uses *Looking at Student Work* to drive the post-lesson discussion protocol of the online coaching cycles.

In another RCT meeting **WWC standards with reservations (Moderate Evidence)**, Sarama et al., (2012) examined the effects of the TRIAD model, which emphasizes teaching early mathematics for understanding via *learning trajectories*. Learning trajectories define developmentally-appropriate paths for student learning; they include a goal, a learning path, and an instructional approach for progressing along the path to meet the goal. The study found that the use of learning trajectories yielded significant improvements in PK-K student mathematics achievement, with even greater effects when teachers were provided with *ongoing follow-up PD and coaching* to support implementation. Integral to our approach is the use of mathematical models and manipulatives embedded within a research-based, coherent learning trajectory. Our PD will focus on helping teachers select and implement inquiry activities using developmentally appropriate models and manipulatives that align with STEM+C content and practice standards. Furthermore, aligned with Sarama et al.'s (2012) findings, our project implements ongoing coaching and support, using vertical teaming across grade levels (PK-2) and professional experience levels (in-service/pre-service) to build sustainable STEM+C learning trajectories.

Third, our study's design closely emulates that of Prime Online (Dana et al., 2017), an

online PD program funded through USDOE/Institute of Education Sciences. Prime Online's intentional and systematic approach to *virtual teacher inquiry* (Dana & Yendol-Hoppey 2019; Dana, 2013), which couples *online coursework* with *inquiry*, has led to increases in Grade 3-5 teachers' CK for teaching mathematics (Pape et al., 2015). Our approach supports teacher development of CK and PCK through a similar virtual PD and coached inquiry framework, extending the model across STEM+C domains and into early childhood.

Magnitude and Reach of Outcomes. Given that the design principles for this project are based on studies of significant success, the *magnitude of the outcomes* attained by the project will have sizeable reach, including impacts on a large number of high-need students through the enhanced instructional competence of participants, as well as broader systemic impacts.

Impacts on high-need students. Within each cohort, we will recruit: 15 teachers for the certificate; 30 teachers for the PD pathway; and 15 candidates for badging. UNF Teacher Candidates will be working in early childhood formal and informal settings each semester that they are completing their badges/microcredentials. Thus, the 45 total candidates will provide STEM+C learning opportunities to approximately 1,620 PK-2 students as they are completing their undergraduate degree. Once they become the teacher of record, these new teachers will impact approximately 4,050 PK-2 students within their first five years of teaching. Additionally, the 90 teachers that complete the PD module pathway will impact approximately 8,100 PK-2 students within the first five years following completion of the program. Finally, the 45 teachers that complete the graduate certificate will impact approximately 4,050 PK-2 students within the first five years of completing the certificate. Following completion, certificated teachers will be recruited to continue their graduate work. Culminating in the M.Ed., which includes an emphasis on teacher leadership development, these emerging teacher leaders will be positioned to provide

job-embedded STEM+C PD to their colleagues. As a result, they will have an exponential impact, spreading acquired knowledge beyond their own classrooms to other educators within their school and the students those educators serve. If each of the 45 teacher leaders cultivated the expertise of 10 other teachers during the next 5 years, they could reach 40,500 additional children in 5 years. In sum, across three cohorts, the 180 teachers and candidates served by **the project will impact the learning of 58,320 PK-2 students** in only a five-year period.

Systemic impacts. In addition to the impact on those directly engaged in the program, InTERSECT demonstrates sustainability of STEM+C professional learning as it results in the **creation of credentials and programs** that will be available to other districts and future UNF teacher candidates. Finally, the project builds a bridge between three key players in the **STEM Ecosystem in Northeast Florida**: STEM2Hub, UNF, and DCPS. The project will strengthen relationships that will facilitate ongoing collaboration on behalf of young children.

B2. Contribution to theory, knowledge, and practices. In a time when accountability has almost dismantled creativity, curiosity, and engagement in the urban classroom, Project InTERSECT cultivates teacher expertise needed to build powerful PBL that supports PK-2 STEM+C learning. To date, little support exists for PK-2 STEM+C integration that pays attention to both impactful instruction and developing teacher expertise. As pioneers in this work, Project InTERSECT will provide pathways to preparing today's teachers for tomorrow's classrooms. The project's significant contributions to theory, knowledge, and practice are inherently aligned with the exceptionality of our approach (Section A1).

Intersections of Academic and SEL. Much has been learned about the positive role of using problem solving, inquiry, and engineering design in STEM+C classrooms, especially in intermediate elementary, middle, and high school settings. Less is known about effective

instructional designs for integrating STEM+C domains within the early elementary grades (i.e., PK-2). In addition, most research focuses on single subject STEM areas (e.g., mathematics or science), omitting the +C (computer science). Some research combines subject areas (e.g., mathematics and science) but, again, leaves off the +C when considering ways to integrate across subject areas. This project is designed to use the overlap within the STEM+C practice standards (Appendix I) to **test the effectiveness of integrating STEM+C content standards in PK-2.**

Similarly, InTERSECT pairs DAP and PBL for young learners with STEM+C Practice Standards to guide classroom implementation. By identifying developmentally appropriate sequences in which STEM+C content standards should be taught, our research findings will **add to existing knowledge of learning trajectories and DAP's impact on student interest in STEM+C.** This knowledge will inform PK-2 preparation and development programs on the mechanisms for supporting teachers to **integrate content that simultaneously promotes SEL,** which has critical implications for the long-term success of high-need PK-2 students.

Collaborative inquiry. As discussed above, the efficacy of collaborative inquiry, including coaching and PLCs, is well-established. Much of the research on inquiry for STEM+C teaching, however, has been conducted with teachers of grades 4 or above. From a practice standpoint, because formal STEM+C education often begins in these later grade levels, this is a content area where early childhood educators have limited access to PD. Project InTERSECT will add to research and practice by building and testing the effectiveness of an expanded set of online **STEM+C collaborative inquiry tools specifically for early childhood educators.** Through our adaptation of evidence-based models, and expansion, testing, and refinement of these approaches for PK-2 educators, we will **identify virtual STEM+C collaborative inquiry protocols for PK-2 teachers** to be used in districts throughout Florida and across the country.

This approach has critical implications for developing PD that “fit(s) teachers’ busy schedules, that draws upon powerful resources often not available locally, and that can provide real-time, ongoing, work-embedded support” (Whitehouse et al., 2006, p. 13).

Furthermore, evaluation of InTERSECT will build knowledge of **differential needs of PK-2 educators in STEM+C** and **specific, replicable approaches to addressing them**.

Because of its iterative design and systematic study of implementation fidelity (see Section D2), the framework and practices refined over the course of the project will enable the InTERSECT model to be **replicated in other school districts across the country**. Our dissemination methods (B3), which include development of a video bank of STEM+C lessons for PK-2 teachers, will ensure **open access to important resources** for practitioners.

Finally, the project proposes a model whereby self-directed collaborative inquiry and personalized paths toward professional enhancement result in increases in teacher and student outcomes. Our model highlights the importance of motivational aspects of the PD as mechanisms through which these outcomes are maximized. Using an adaptation of the Motivational Climate Assessment (MCA; Pritchard, 2008), we will measure the extent to which the PD context possesses characteristics that promote participant motivation. The evaluation will test the extent to which InTERSECT activities enhance teacher perceptions of the quality and relevance of PD, coaching support, feedback, and peer collaboration, and whether these perceptions in turn impact teacher practice and student achievement. While there is an underlying understanding in the educational research community that “motivation matters,” no studies to our knowledge have explicitly investigated a mediated model, whereby motivational aspects of PD mediates effects of PD on practice and achievement. Testing this model will **expand knowledge of the underlying processes through which PD impacts student outcomes**.

Cost-effective PD and Credentialing. Aligned with researchers' calls for focused studies on the design, implementation, and impacts of chunked learning (e.g., microcredentials; DeMonte, 2017), Project InTERSECT will add to knowledge and practice by **testing a system of stacked credentials for developing a pipeline of STEM+C expertise**. Dosage, defined in this study as an exposure to a professional learning experience in measured portions, will be examined to determine the variable effectiveness of the two parallel pathways for in-service teachers (graduate certificate or PD credit; see Research Questions-D3). The two dosages, distinct in depth and comprehensiveness, will be compared to build knowledge of the level of intensity/dosage necessary to make an impact on teacher and student learning. Implications from our findings offering insight to others in **designing cost-effective, sustainable, and replicable approaches to teacher PD and enhancement**, while concurrently **increasing the relevance and affordability** of PD and advanced credentialing for teachers of high-need students.

B3. Dissemination strategies. Project strategies and outcomes will be disseminated to ensure that educators committed to strengthening STEM+C experiences of high-need PK-2 students across the country are able to replicate the project. Dissemination mechanisms have been designed for practitioners, researchers, and policy-makers. PK-2 teachers will be provided on-line strategies and a video bank of STEM+C lessons to integrate STEM+C domains into their instruction. Teachers will be given **open access to collaborative inquiry protocols** and personalized, job-embedded PD on the developmentally appropriate use of problem solving that integrates STEM+C content with strategies to promote SEL. The badging and certification curriculum and materials, including lesson plans, videotaped material on effective pedagogy, and other curricular materials aligned with state standards developed by InTERSECT will be made available on the UNF Digital Common website. Findings, including at least one **impact study**

meeting WWC standards, will be disseminated in **scholarly and practice-focused refereed journals** in which InTERSECT personnel have successfully published, including: *Journal of Teacher Education*; *Educational Researcher*, *Action in Teacher Education*; *Teachers College Record*; *Journal of Experimental Education*; *International Journal of Science Education and Mathematics Education*; *Learning & Instruction*; *Educational Psychology Review*, and others.

Practitioner/researcher presentations will be selected to maximize access to stakeholders at multiple levels, and include practitioner conferences in Florida (e.g., Florida Association of District School Superintendents) and national conferences including AERA, AACTE, NCTM, and others. Finally, Project InTERSECT will develop mechanisms for **building local, state, and national policy maker and staff expertise**. Building on the strong support for the project documented in Appendix D, a small work team composed of leaders of the InTERSECT partnership along the Florida Institute of Education will develop a set of dissemination strategies aimed at building political capacity and support to ensure sustainability of this effort.

C. Quality of the Management Plan.

C1. Goals, objectives, and outcomes. The project aims to achieve three primary goals.

Objectives, outcomes, and measures for each goal are below (data sources, measurement tools, and data collection timelines are detailed in Section D and Appendix J).

Goal 1. Increase STEM+C achievement of PK-2 students. This goal aims to achieve three objectives: (a) Develop PK-2 teacher CK and PCK in STEM+C; (b) Promote student interest in STEM+C; and (c) Promote student self-regulation. Outcomes of this goal (measures in parenthesis) are increases in *teacher knowledge and use of strategies* for promoting student interest in STEM+C and self-regulation (% of teachers exhibiting increased levels of observed CK and PCK; % of classrooms with high observed levels of engagement and self-regulated

learning); *student achievement* in mathematics, science, and computer science (% of students on or above grade level; % of student explanations of their work indicating at least basic levels of knowledge); *student interest* in STEM+C (% of teacher-rated student interest at high levels); and *student self-regulation* (% of student explanations of their work indicating high levels of SR).

Goal 2. Increase the STEM+C efficacy of PK-2 teachers. This goal includes two objectives: (a) Provide self-directed professional learning opportunities supported through inquiry; and (b) Provide personalized, stackable pathways for professional learning and enhancement. Intended outcomes are increases in: *teacher self-efficacy* for STEM+C instruction (percent of participants who self-report positive self-efficacy); *teacher perceptions* of the quality and relevance of PD, support, and feedback (percent of participants who report high levels of quality/relevance of PD, coaching support, and feedback); *teacher collaboration* (percent of teacher observations exhibiting use of collaboration); *teacher practice/effectiveness* (percent of teachers rated effective or higher, and percent of these serving high-need students-GPRA measures); and *teacher retention* (percent of effective teachers who remain in the district-GPRA).

Goal 3. Refine a replicable model for stackable, collaborative, inquiry-driven STEM+C professional learning and enhancement for early childhood educators. Objectives are: (a) Assess the variable impacts of key project components to identify “what works and why;” and (b) Sustain, expand, and build toward systemic impacts. Outcomes are: *high-fidelity implementation* and refinement of the model (as indicated by implementation measures-teacher participation rates, teacher leadership capacity, students impacted, cost per teacher [GPRA]-see detail in C3 and D2); identification of the variable *cost and impact of each pathway* (outcome comparisons across dosages/pathways; cost of participation in each pathway); *sustained impacts*

(percent of teacher practice and achievement effects maintained at follow-up); and *dissemination* of results (number of papers/presentations to researcher and practitioner audiences).

C2. Responsibilities, timelines, and milestones. Project InTERSECT will be led by [REDACTED] a leading researcher in the area of teacher inquiry/teacher professional learning, who will serve as Principal Investigator (PI). Three Co-Principal Investigators (Co-PIs) with expertise in STEM+C curriculum and instruction [REDACTED] and educational psychology/SEL [REDACTED] will provide leadership support. [REDACTED] will support coaching cycle adaptation and development, [REDACTED] will provide early childhood STEM+C PCK support, [REDACTED] will provide early childhood SEL expertise, and [REDACTED] will offer engineering integration expertise. DCPS Instructional Leaders (DCPS-IL), including [REDACTED] (Director of Early Childhood Education), [REDACTED] (K-12 STEM Specialist), and [REDACTED] (Supervisor of Elementary Science), will manage the availability of teachers for each component of the PD, support the incorporation of their work into classrooms, and facilitate sharing internally throughout DCPS. External evaluation will be led by [REDACTED]ight, who is trained in WWC design standards and has extensive experience evaluating USDOE-funded grants.

The Leadership Team (LT), which will include the PI/Co-PIs and representatives from DCPS and STEM2Hub, will provide overall leadership to all aspects of the project. Project activities are overviewed in Table 3 (Evaluation Management Plan is provided in Appx. J).

Table 3. Overview of Management Plan: Milestones, Responsibilities, & Timelines

Major Milestones	Responsibility	Yrs	Timeline
<i>Select key stakeholders to serve on Leadership, Instructional, District/School Advisory, & Evaluation Teams and define within- and across-team communication processes.</i>			
Develop MOUs/contracts	LT	1	12/1/20

Schedule Leadership Team (LT) meetings	PI, Co-PI	1-3	Monthly starting 11/20
Schedule Evaluation Team (EV) meetings	LT,rEV	1-3	Monthly starting 1/21
Add reps of target schools to DCPS-IL	LT, DCPS-IL	1	6/1/20 (annual review)
<i>Develop/refine course content and classroom observation tools.</i>			
Develop STEM+C coursework including collaborative inquiry strategies for the 3 pathways	LT	1	Target: May 2021
		2-3	Review: Semi-annually
Develop and test classroom observation tools and a rubric for assessing teacher skills in integrating content and inquiry strategies	LT	1	Target: May 2021
		2-3	Review: Semi-annually
Design Implementation Fidelity Alignment tool	LT,rEV	1	Target: Jan 15, 2021
Purchase and install equipment, software, and licensing for Distance Learning / provide training	LT, DCPS-IL	1	Installation: 1/15/21; Training: 1/30/21
Implement technology platform for collaboration; sharing and documenting portfolios; and supporting virtual coaching	LT	1	Installation: 1/15/21; Training: 1/30/21
Expand/enhance the existing the UNF COEHS Telepresence Lab for the Inquiry Showcase; the STEP Lab for modeling video work; UNF's Digital Commons for video lesson bank	LT	1	Installation: 1/15/21; Training: 1/30/21
Design/refine PK-2 curriculum for advanced STEM+C courses including integration of Professional Badges and Grad Certifications	LT, DCPS-IL	1	Target date: March 15, 2021
		2-3	Review: Semi-annually
<i>Recruit in-service and pre-service teachers</i>			
Develop recruitment/selection materials/processes	LT, DCPS-IL	1	2/1/21 (annual review)
Recruit 15 candidates per cohort from UNF's COEHS undergrad teacher prep program	LT, DCPS-IL	1-2	Coh.1: 5/1/21; Coh.2: 7/1/21; Coh.3: 5/1/22
Recruit 15 PK-2 teachers per cohort from selected schools to participate in Certification pathway	LT, DCPS-IL	1-2	Coh.1: 5/1/21; Coh.2: 7/1/21; Coh.3: 5/1/22
Recruit 30 PK-2 teachers per cohort from selected schools to participate in PD credit pathway	LT, DCPS-IL	1-2	Coh.1: 5/1/21; Coh.2: 7/1/21; Coh.3: 5/1/22

<i>Provide PD/coursework and collaborative inquiry to PK-2 teachers and candidates to support the integration of STEM+C content and SEL into instructional practice.</i>			
Provide Segments 1-4 for Cohort 1	LT, DCPS-IL	1-2	Starting Jun, 2021
Provide Segments 1-4 for Cohort 2	LT, DCPS-IL	1-2	Starting Sept, 2021
Provide Segments 1-4 for Cohort 3	LT, DCPS-IL	2-3	Starting Jun, 2022
Purchase and install video-recording equipment (Swivls), software, and licensing for K-2 schools	LT, DCPS-IL	1	Target: 5/1/21; Training: 5/15/21
Facilitate ongoing virtual coaching and PLCs	LT, DCPS-IL	2-3	Oct 2020, ongoing
Award badges and certifications/graduate credits to teachers completing PD	LT, DCPS-IL	3	Coh. 1: June, 2022 Coh. 2: Jan, 2023
Recruit, screen, and enroll teachers selected for graduate program	LT	3	Coh. 1: May 2023 Coh. 2: Aug 2023
<i>Empirically investigate the effectiveness of InTERSECT; prepare for replication/expansion.</i>			
Develop formal facilitator training modules; refine protocols for replication and expansion	LT, DCPS-IL,	1	Jun 2021
	EV	2-3	Review/refine: ongoing
Disseminate results	LT, rEV	2-3	Aug 2022; ongoing

An Advisory Board will provide the LT with feedback and strategic recommendations for implementing and achieving project objectives. Advisory Board members will include (a) expert practitioners in STEM+C, (b) educational researchers including [REDACTED] [REDACTED] (cited above), and (c) DCPS district and school leaders. See letters of support-Appx D.

C3. Feedback and continuous improvement. Iterative assessment, feedback, and continuous improvement are embedded in the design and evaluation of the project. Coupled with quarterly formative evaluation feedback and collaboration of all stakeholders, the phased implementation timeline (Table 1, p. 14) allows for timely, data-driven iterations in both design and evaluation.

Implementation fidelity and improvements to design. Program processes will be examined continually for fidelity, allowing for identification of context-specific challenges in need of adaptation (Meyers & Brandt, 2015). The phased implementation will enable fidelity

data to be used for collaborative problem-solving and to improve program delivery prior to expansion to Cohort 3, thereby **maximizing impact** on student outcomes (Kershner et al., 2014) and **minimizing costs** of program changes (Williams & Cockburn, 2003).

Evaluators will assess implementation quantitatively and qualitatively. Quantitative measures include: Participation and completion rates (overall and per pathway); cost per participant (GPRA); number of students impacted; number of coaches trained; and coaching hours (per teacher). Qualitative assessment methods include (details and protocols are provided in Appx. J): PD and coaching observations (video-recorded and expert-coded); evaluator-led focus groups with participants, faculty, and school leaders (three per pathway with each cohort); classroom observations (principal- and faculty-conducted); video-recorded lessons/student-teacher interactions; and expert-coded student explanations of their work (see below). These data will form the basis for an Implementation Fidelity Alignment (IFA) Tool to be developed collaboratively by evaluators and project staff. Designed for use by program implementers to continually assess fidelity and areas for improvement, the IFA tool will specify indicators and operational definitions of implementation components, data sources, rating criteria, and rubric. Evaluators will also conduct a formal **implementation study** (see section D2), designed to identify key intervention components, providing critical feedback regarding processes necessary for sustaining, replicating, and expanding the work. Project leaders will meet quarterly with evaluators to incorporate results of formative evaluations/fidelity assessments into their work. Guided by principles of developmental evaluation (Patton, 2016), evaluators will, in turn, use project feedback to adapt evaluation plans as needed (at least annually).

Project-generated feedback. Artifacts generated through teacher inquiry will also provide critical feedback to the program. First, as part of the inquiry cycle, participants will

submit video-recorded lessons at least once per segment. Researchers will score the videos using the Mathematical Quality of Instruction (MQI; Hill et al., 2008) observation protocol, which will be adapted to also capture science and computer science instruction, to provide an indicator of CK and PCK across STEM+C domains. Second, teachers will audio or video record their students explaining a product and the process they used to create the product. Teachers will submit recordings of student explanations at least twice per learning segment (8 explanations per student over the course of each school year). A subset of these recorded student explanations of their work will be transcribed and coded by researchers using a coding scheme for preschoolers' explanations of science concepts (Peterson & French, 2008), which will be adapted for mathematics and computer science, providing insight into students' STEM+C knowledge. As students explain their learning process and the artifact, language about their perceived challenge, choice, and collaboration will emerge, giving insight into students' problem solving strategies. Thus, a separate coding scheme for self-regulation (Whitebread et al., 2009) will be used.

This approach will provide rich qualitative and quantitative data on critical project outcomes for informing program implementation and identifying teacher needs. In addition, this approach provides useful feedback to participants, offering teachers practice assessing student inquiry and self-regulatory behaviors and providing the foundation for coaching conversations. They can include artifacts or recordings in their virtual coaching sessions or PLCs, and may use student explanation or observation interaction data in their portfolios as part of their capstone.

D. Quality of the Project Evaluation

D1. Meets WWC standards with reservations. The evaluation employs a cluster-level QED designed to meet WWC Standards with Reservations. The study will examine: (a) the impact of Project InTERSECT on student outcomes, (b) its impact on teachers, (c) mediating effects of

teacher knowledge, perceptions, and behavior, and (d) implementation fidelity, identifying the factors related to maximum student and teacher outcomes (see Research Questions in D3).

Sampling. The intervention will take place across three cohorts of in-service teachers and teacher candidates. Teachers will be recruited from DCPS high-need elementary schools identified above (with recruitment efforts prioritized in QOZs). Candidates will be recruited from among students in their junior year of UNF's undergraduate teacher preparation program. In each cohort, teacher participants will be matched with non-participating business-as-usual (BAU) teachers from the same pool of high-need schools. Candidates will be matched twice: first, with non-participating undergrads in UNF's teacher prep program (this allows for examining formative variables including perceptions during the intervention); and second, with non-participating first-year teachers at DCPS high-need elementary schools (during Year 3 [outcome year], candidates will be in their first year of teaching). Propensity Score Matching (PSM) will be used to account for measured differences between treatment and BAU comparison groups (Rosenbaum & Rubin, 1985) and to ensure baseline equivalence of student-level clusters that meets WWC's threshold (*Hedge's* $g < 0.25$; WWC, 2020). Participants will be matched on pretest measures of outcomes used in final analyses (student achievement; teacher practice scores); teacher experience and grade level; and student race and SES (free-reduced lunch).

Annual implementation studies (see D2) will be conducted in years 2 and 3. A full-scale **impact study** (see D3) meeting WWC standards, based on the combined sample from Cohorts 1 and 2, will be conducted in Year 3, with sustained effects and impacts from Cohort 3 examined beyond the period of grant funding. The research activities shown in blue (Table 4, following page) are those proposed to be conducted through SEED funding.

Conservatively assuming a 15% attrition rate, we estimate 4,335 students will be matched

across 255 teachers (total in both conditions across cohorts 1-2). **Power analysis**, in the context of a Difference-in-Differences design accounting for clustering of students within teachers, yields a minimum detectable effect in the Year 3 impact study of 0.11 for student outcomes (0.25 for teacher outcomes), estimated using PowerUp! (Dong & Maynard, 2013). Assumptions were: Power 80%; α .05; R^2 at student and teacher levels 0.5 (using pre-treatment measures of achievement and demographics). Analytical approaches are described in section D3.

Table 4. Study Sample and Research Timeline

Cohort	Study Sample				Research Timeline							
	Treatment (n)		BAU (n)		Full Analytic Sample (n)		Study focus	Y1	Y2	Y3	Post-grant	
	T/TC	Students	T/TC	Students	T/TC	Students						
1, 2	120	2,040	180	3,060	300	5,100	Implementation	X	X			
							Impact			X	X	
							Sustained effects					X
3	60	1,020	90	1,530	150	2,550	Implementation		X	X		
							Impact					X
							Sustained effects					X
1, 2, 3	180	3,060	270	4,590	450	7,650	Impact				X	

Notes: T Teachers; TC Teacher Candidates; BAU Business as Usual. Each cohort contains multiple pathways; Treatment sample (each cohort) includes n 15 teachers in certificate pathway (n 25 BAU), n 30 teachers in PD pathway (n 40 BAU), and n 15 candidates in badging pathway (n 25 BAU).

D2. Performance feedback and progress toward intended outcomes. Quarterly formative evaluation reports will provide a formal mechanism for delivering *short-cycle feedback* to project leadership (see section C3). Quarterly reports will include assessment of formative measures of outputs and expected outcomes in the logic model as early indicators of project effectiveness. These formative measures (including project-specific and program/GPRA measures) will be used to assess *progress toward goals and objectives* during the treatment years and evaluate *trends over time*. Student achievement in mathematics, science, and computer science and students' self-regulation will be measured formatively using student explanations of their work (at least 2 per student per semester), as described in section C3. A random sample of

student explanations will be coded by researchers using coding schemes developed by Peterson and French (2008) and Whitebread et al., (2009). Teacher practice and collaboration will be assessed annually using data from principal-conducted classroom observations. Teacher knowledge and use of strategies will be assessed four times throughout the project (at baseline, after segments 2 and 4, and at the end of Year 3) using the MQI (Hill et al., 2008) and Self-Regulated Learning (Perry et al., 2002) observation protocols. Previous research indicates levels of interrater reliability exceeding WWC standards (see Appx. J). Interrater reliability training will be provided, and videos/transcripts will be coded by multiple raters until interrater agreement is established. Teacher perceptions (self-efficacy, perceptions of PD), teacher leadership capacity, and teacher-reported student interest and self-regulation will be assessed formatively (at baseline, after segments 2 and 4, and at the end of Year 3) using the surveys described in section D3. Focus groups will be conducted to enrich survey data (Additional details on formative measures and reporting, including a timeline of activities, are provided in Appx. J).

Implementation study. A primary goal of the project (Goal 3) is to identify critical components of the project to sustain, replicate, and expand the work. To supplement formative evaluation, the evaluation includes a formal **study of implementation fidelity** aligned with IES' protocols (Abt Associates, 2019). Implementation evaluation utilizes a **mixed methods design**, whereby qualitative data are used to explain and enhance quantitative implementation and outcome data (Creswell & Plano Clark, 2007). This design supports innovative, adaptive program development (Patton, 2016) and provides context and conceptual clarity in defining key intervention and program implementation components (Bishop, 2015). Implementation data, which include measures of program activities and outputs (see logic model), will be collected quarterly, fed back to project staff, and integrated into outcome analyses (see Research Questions

3-4 below) to identify optimal approaches and critical processes for sustaining/replicating results.

D3. Performance measures related to outcomes and produce quantitative/qualitative data.

Aligned with key project components, outputs, and outcomes in the Logic Model (B1), and the goals, objectives, and measures (C1), the study will address three primary **Research Questions:**

RQ1. What is the impact of InTERSECT on student outcomes? The study tests the extent to which the intervention results in improvements in student **(1a)** interest in STEM+C; **(1b)** self-regulation; and **(1c)** achievement in STEM+C. ***RQ2. What is the impact of InTERSECT on teacher outcomes?*** The study tests the extent to which the intervention results in improvements in teacher **(2a)** practice; **(2b)** self-efficacy for STEM+C instruction; **(2c)** perceptions of the quality/relevance of PD, coaching support, and feedback; and **(2d)** retention in the district. ***RQ3. What is the impact of dosage?*** Specifically, this research addresses the two treatment pathways for in-service teachers (i.e., two dosage levels: graduate certification and PD credit), examining the extent to which dosage impacts student and teacher outcomes and the value added by the deep dive certificate pathway for aspiring teacher leaders. ***RQ4. What variables explain the impact of InTERSECT on student outcomes?*** The study tests the mediation effects of teacher knowledge/perceptions/practice in explaining student outcomes.

Outcome Measures will be collected for treatment and BAU groups (**Cohorts 1-2**) in **Year 3** (2022-23). See Appendix J for details on data collection, measures, and scale properties.

Student Achievement Outcomes. Pre-K students' mathematics achievement will be measured using the Florida Kindergarten Readiness Screener (FLKRS); K-2 students' mathematics achievement will be measured via i-Ready Math. These are standardized diagnostic assessments which meet WWC validity requirements. PK-2 students' general STEM knowledge will be captured using the Peabody Picture Vocabulary Test (PPVT-5; Dunn, 2018). The latest

version of the test includes STEM-specific vocabulary words. The PPVT has established evidence of validity and reliability ($\alpha = .97$) related to measuring PK-2 children's receptive vocabulary knowledge. These assessments, which will be administered at the beginning and end of the school year, are aligned with WWC review protocols for Primary Mathematics (ver. 4.0) and Primary Science (ver. 4.0). Students' explanations of their work, as described in sections C3 and D2, will provide additional outcome measures of student achievement.

Teacher Practice. Teacher practice will be measured using DCPS' Collaborative Assessment System for Teachers, which is built on Danielson's Framework for Teaching. Data will be collected separately for each of four observation domains, which collectively assess instruction/pedagogy and professional responsibilities. CK and PCK will be measured using the Mathematical Quality of Instruction observation protocol (Hill et al., 2008), which will be adapted to include measures of science and computer science knowledge. Teacher retention in the district will be measured using DCPS records. Each of these meets WWC validity/reliability requirements (Kane & Staiger, 2012) and is aligned with WWC review protocols for examining Teacher Excellence (ver. 4.0). Use of strategies for promoting student interest self-regulation will be measured using Perry et al.'s (2002) observation protocol for Self-Regulated Learning.

Teacher Beliefs/Perceptions will be tested as mediators in impact analyses. These data will be collected via surveys with demonstrated validity and internal consistency reliabilities that exceed WWC standards. Two self-report instruments will be used to measure teachers' self-efficacy beliefs related to STEM+C: the Science Teaching Efficacy Beliefs Instrument (STEBI; $\alpha = .92$; Riggs & Enochs, 1990) and the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI; $\alpha = .75-.88$; Enochs, Smith, & Huinker, 2000). Teachers' perceptions of the quality and relevance of PD, coaching support, and feedback will be measured using the Motivational

Climate Assessment (MCA; α .83; Pritchard, 2011), which assesses the motivational aspects of professional learning environment. Teacher leadership will be measured using Lowe et al.'s (2019) instrument to capture shifts in innovative practice and comfort in active leadership roles.

Student SEL/Behavior Outcomes. Researcher-coded student explanations of their work, as indicators of self-regulation, meet criteria for WWC eligible student social-emotional learning/behavior outcomes in the *Student Engagement in School* domain. Perry's (1998) Self-Regulated Learning survey will be adapted to address STEM+C domains, and will provide an additional measure of student self-regulation, and of student interest in STEM+C (teacher-rated).

Analytical Approach. The impact of INTERSECT on **student (RQ1)** and **teacher outcomes (RQ2)** will be assessed using a Difference-in-Differences (DD) design. DD allows for examination of changes in treatment and BAU groups before and after implementation of the intervention. DD designs yield valid causal inferences about intervention effectiveness and can meet WWC standards when they include a matched comparison group (Somers, Zhu, Jacob, & Bloom, 2012; Shadish, Cook, & Campbell, 2002; WWC, 2020). **Moderation analyses (RQ3)** will be conducted to test the interaction effects of teacher dosage in predicting student outcomes. **Mediation analyses (RQ4)** will be conducted to determine the proportion of variance in student achievement accounted for by teacher knowledge, behavior, and perceptions.

Impacts will be estimated using a two-level Hierarchical Linear Model (HLM) to account for students nested within teachers (Raudenbush & Bryk, 2002). Following WWC standards, the analytic sample will include participants from treatment and comparison groups with both pretest and outcome scores. Analyses will determine whether and the degree to which group differences are statistically significant (i.e., by calculating effect sizes, *Hedges g*) using appropriate multiple comparison corrections (Benjamini & Hochberg, 1995).

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