Supporting and recovering science learning loss with a game-based learning approach leveraging a school-university partnership

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Abstract: This study describes the process of forming a school-university partnership to support the professional growth of our pre-service teachers and the in-service teachers at one partner school district and improving middle school students' science learning amid the pandemic.

KEYWORDS: science education, game-based learning, school-university partnership, teacher professional development, clinical experience

NAPDS Revised Nine Essentials Addressed:

Essential 2: A PDS embraces the preparation of educators through clinical practice.

Essential 3: A PDS is a context for continuous professional learning and leading for all participants, guided by need and a spirit and practice of inquiry.

Essential 4: A PDS makes a shared commitment to reflective practice, responsive innovation, and generative knowledge.

Essential 7: A PDS is built upon shared, sustainable governance structures that promote collaboration, foster reflection, and honor and value all participants' voices.

Essential 9: A PDS provides dedicated and shared resources and establishes traditions to recognize, enhance, celebrate, and sustain the work of partners and the partnership.

Introduction

COVID-19 has made a tremendous impact on student learning around the globe (Van Lancker & Parolin, 2020). In Indiana, and throughout the United States, the pandemic resulted in significant learning deficits among K-12 students (Indiana Department of Education, 2021). The data released by the Indiana Department of Education (IDOE) in 2021 shows that only 37.5% of the 3rd to 8th grade students in Indiana meet the grade level proficiency in science. Minority students, students with low socioeconomic status, and English language learners all suffered a significant academic impact that will require learning recovery time of more than one year. To address Indiana students' deficits in learning, the IDOE offered the Student Learning Recovery Grant Program and Fund, calling for the partnership of public and non-profit organizations to provide learning recovery and remediation services for K-12 students who demonstrate a deficit in learning as a result of disruptions to in-person learning caused by the pandemic.

In response to the IDOE's call, our university formed partnerships with the area's school district and non-profit organizations, using a community-based approach to accelerate student learning in math, literacy, and science. The authors of this paper, and one of the teams in this larger grant project, are responsible for supporting students' science learning through the formation of a partnership with middle school science teachers at the traditional public schools in the community and a charter school with close ties to the university. Through this school-university partnership, we leveraged a game-based learning (GBL) approach (Gee, 2006) to provide ongoing support for in-service science teachers to revise their curricula and enhance both learner motivation and instructional effectiveness. We also created opportunities for university teacher candidates to partner with participating schools and offer remedial tutoring services for struggling learners. An added benefit to pre-service teachers in our secondary practicum sequence whose placement for field experiences occurs in the classrooms of teachers participating in this initiative is the opportunity to observe in-service teachers as they integrate GBL into their teaching.

This study describes the process of forming the school-university partnership to support the professional growth of our teacher candidates and the in-service teachers at one of our partner school districts, Muncie Community Schools (MCS), while improving middle school students' science learning in the midst of the pandemic. First, we will describe the roles and contributions of different stakeholders that led to the formation of this collaboration. Next, we will discuss the successes and ongoing challenges of supporting students' science learning with the GBL approach through the school-university partnership.

Relevant Concepts and Literature

In this section, we provide an overview of the challenges in STEM education and offer research-based rationales for using game-based learning and school-university partnerships as the collaboration model for addressing issues in STEM education.

The Challenges in Science Education and Game-Based Learning

Many middle school students struggle in science classrooms due to the abstractness and complexity of science concepts. These challenges often exist when reading science texts that typically contain unfamiliar terms and complex sentences that create barriers for comprehension (Dori et al., 2018; Johnstone, 1991). Furthermore, as studies have shown, motivation to learn plays an important role in conceptual learning tasks such as learning scientific concepts (Hsieh, 2014; Wentzel & Miele, 2016). Students with low motivation to learn need further support to remove the challenges inherent in learning science concepts and skills. Without such support, these students may be less motivated to learn science, and thereby their learning performance will be negatively impacted (De Loof et.al., 2021)

The game-based learning (GBL) approach has the potential for alleviating learning challenges in science education (e.g., Al-Tarawneh, 2016; Law & Chen, 2016). Studies indicate the use of GBL learning increases student motivation and science learning (e.g., Al-Tarawneh, 2016; Hussein, et al., 2019). However, to successfully implement GBL in K-12 classrooms, teachers need to learn about GBL in general and extend their understanding of content, teaching methods, and technology tools and resources used for games (Foster & Shah, 2015; Tzuo et al., 2012). Without support and training, it is unlikely that teachers or schools will adopt and sustain the use of GBL effectively (Tzuo et al., 2012). Our school-university partnership helps address this gap. We are able to offer the training, resources, and support the 5teachers need for implementing GBL. In return, the teacher participants and their students have shared valuable insights into the applications of GBL and have provided teacher candidates at our university the opportunity to gain critical field experience and observe GBL in action.

Shortage of Quality STEM Teachers. Over the last two decades, the U.S. has continued to experience a shortage of qualified STEM educators in math and science despite policies to increase the overall STEM workforce (Feder, 2022). An increase in K-12 STEM teachers is also necessary to prepare the next generation of STEM professionals to fuel the economy and expand STEM-related development. The U.S. lags behind in granting undergraduate science and math degrees (National Science Board, 2016). This has contributed largely to a shortage of teacher candidates and in-service teachers in math and science fields. Over 40 states have identified teacher shortages in the fields of math and science (U.S. Department of Education, 2022). Feder (2022) also mentioned that “in science, technology, engineering, and math (STEM) fields more broadly, the shortages in teachers in 2017–18 were about 100000 in high schools and 150000 in middle schools” in the United States.

In the case of science, even when schools can fill these openings in middle and high positions, teachers are often not certified in their current job (Sutcher, et al., 2019) or received significantly less preparation in pedagogies compared to teachers in other fields. Science teachers (40%) were twice as likely as math teachers (21%) to have completed no student teaching practicum or experience before their first year (Ingersoll et. al., 2014); thereby lacking pedagogical and/or content knowledge essential to positively impact student learning. These teachers often struggle to connect content knowledge to pedagogical approaches that best encourage the knowledge building needed to effectively teach the students in their classrooms. A lack of clinical practice also impacts attrition as they often struggle with class discipline and lack of administrative support (McConnell, 2017).

To address the shortage of certified science teachers in middle and secondary schools, both in-service teachers and teacher candidates need professional learning and instructional support. The increased support to in-service teachers could also potentially stymie attrition (Ingersoll et. al., 2014). To that end, our project aims to leverage a school-university partnership to help impact science students’ learning through increasing teacher pedagogical knowledge. We address both teacher candidates’ and in-service teachers’ professional learning needs and assist both teachers and students to feel supported in science education.

Leveraging School-University Partnerships

In 1998, MCS teachers and administrators across grade levels and schools were invited by the Dean of the Teachers College to investigate the Professional Development School model (Holmes, 1990; National Association of Professional Development Schools, 2008; 2021) to decide whether investing in a formal PDS relationship with Teachers College was something they were interested in pursuing. This "bottom-up" approach in which "buy-in" by teachers is fundamental and reflects a recognition of P-12 teachers' expertise and agency in identifying both individual and school-wide efforts necessary to improve student achievement is a defining characteristic of PDSs (Holmes Group, 1990; Johnson, 1990). Based on overwhelming support on the part of district teachers and administrators, the Muncie Community Schools and the Ball State University's teacher preparation programs entered into a formal partnership in 1999. Characterized by both school-specific foci and concerns relevant to all schools in the corporation, collaborative efforts were teacher-driven and facilitated by the assignment of university-based liaisons. Over the next eighteen years, this school-university partnership resulted in numerous initiatives designed to improve student success, build schools' capacity to host teacher candidates for transformative field experiences, and support the initiation of and participation in a variety of research projects. The teachers' central and pivotal role in first choosing to participate in such a partnership and then in defining the focus of much of the professional development and research activities cannot be over-emphasized.

The relationship between the Muncie Community Schools and Ball State University fundamentally changed; however, in 2017 when the district was labeled as "distressed" by the IDOE. The designation was a result of decreasing enrollments caused by economic flight, financial misappropriation by previous school managers, low performance on standardized tests, and high rates of poverty within the community, thus leading the state DOE to initiate a school takeover process. In 2018, a resolution by the state's General Assembly opened the way for Ball State University to assume the management of the school district. Over the last three years, the relationship between the university and district has addressed financial issues, increased human capital, and supported innovative pedagogies to improve student learning. However, the relationship between the school corporation and university has shifted away from a Professional Development School model as framed by the Holmes Group (1990) and the National Association of Professional Development Schools (2008; 2021) to a more "top-down" model with many decisions arrived at between school and university administrators (Collins, 2014). While this newer partnership between the university and the community it serves continues to evolve, it is important to point out that the project described in this article was implemented in a spirit more aligned with the tenets of Professional Development Schools as defined by the Holmes Group (1990) and the National Association of Professional Development Schools (2008; 2021). Although Ai-Chu Ding (the first author and the GBL project coordinator), was designated as the sole communicator with the district's Associate Superintendent, the team met with teachers to better understand their professional development needs and their perceived struggle in the classroom in meeting student's learning needs. The university personnel's approach in working with participating middle school teachers was more aligned with the collaborative way in which the school district teachers were used to working under the Professional Development School model. Predicated on building mutually respectful relationships that facilitated the goals of both school and university professionals, the GBL initiative leveraged classroom teachers' knowledge of student and classroom contexts while increasing teachers' knowledge and use of GBL to increase student learning in science. This mutualistic aspect was ideal as several university personnel with expertise in different fields worked with different areas of instructional practice in MCS.

Context and Project Description

Context

Muncie Community Schools (MCS) is a mid-sized urban school district situated in the Midwest. In the mid-1970s to ’90s, the city was served by industrial and manufacturing companies that employed many in the community (Delaware County, IN, n.d.). After an economic downturn that shuttered many of the city’s manufacturers and employers during the first decade of the 2000s, the city has bounced back but shifted to healthcare and education sectors for employment which represent the city’s main employers.

MCS is a diverse district with approximately 5,000 students educated within a single high school, two middle schools, six elementary schools, and a youth opportunity center (i.e., alternative school program). The two middle schools, Northside (NMS) and Southside (SMS), serve approximately 550 and 580 students. Students at these schools share demographic features of the overall district, where 57.4% of students identify as white, 21.5% of students identify as African-American, 15% of students identify as multi-racial, and 5.3% of students identify as Hispanic. Just over half (58.4%) of the district’s students receive free or reduced-price meals representing a decrease from 75.8% two years ago.

Approximately 20% fewer students in grades 3-8 scored at proficiency or higher in English language arts (ELA) and math on state standardized tests compared to the statewide percentage of students who scored at the same level. NMS students scored approximately 12 percentage points higher in science and ELA than SMS students and approximately five percentage points higher in math (see Table 1).

Table 1
Percentage of students scoring proficient or higher on state standardized tests (SDOE)

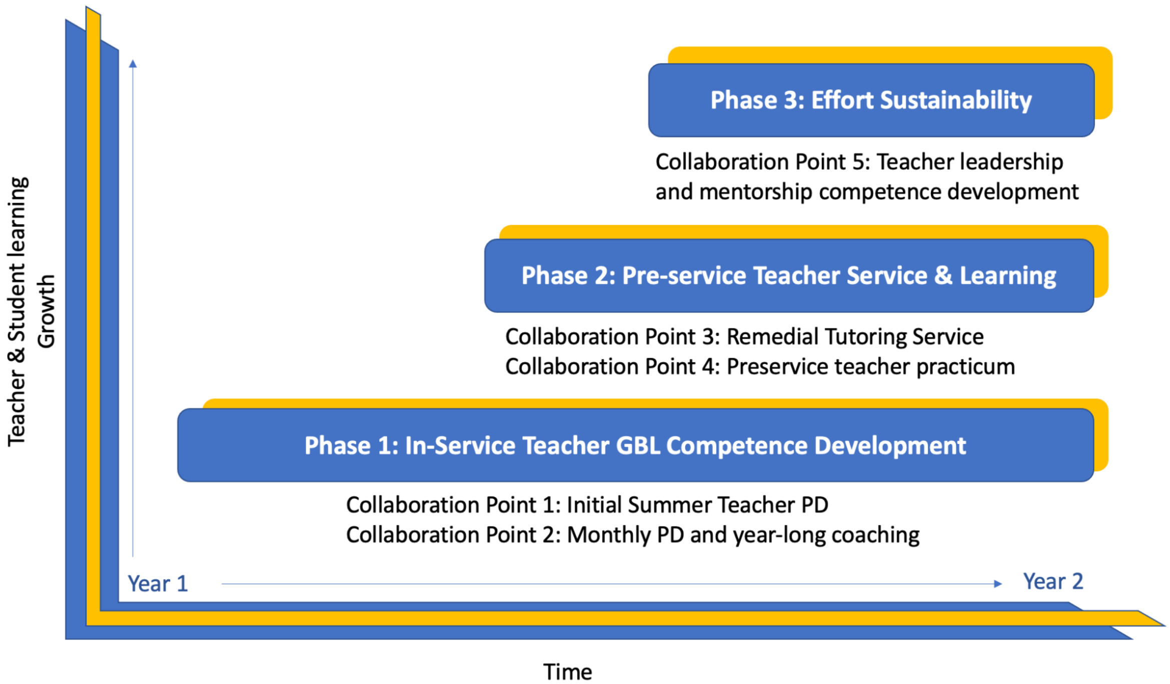
School	ELA (%)	Math (%)	Science (%)
Northside MS	33.9	24.2	35.2
Southside MS	20.8	19.8	25.3
MCS (Grades 3-8 only)	27.6	28.3	29.9
State Average (Grades 3-8)	47.9	47.8	47.4

Almost 400 teachers work in the district; all teachers were rated as effective or highly effective in the previous year. Most teachers in the school district have sixteen or more years of teaching experience (40%), while 35% of teachers are in their first five years of teaching, and 25% have between five and fifteen years of experience.

Project Description

This project aims to leverage a school-university partnership to increase both in-service teachers and pre-service teacher candidates’ competence in incorporating GBL middle grade science classrooms. As this approach is a relatively new concept to both our school teachers and our teacher candidates, we created a three-phased model (Figure 1) where five major collaboration points are carried out throughout the period of two years.

Figure 1
Our School-University Partnership Model



During Phase 1, the goal was to increase science teachers' GBL competence and ensure they have the infrastructure (e.g., allotted time for professional development and lesson development, program licenses and hardware) and resources (e.g., curricula mapping, games that align with learning objectives, Breakout.edu kits, and pedagogical support) they needed to implement GBL in their classes. This will be an ongoing effort across both years of the project. But we also anticipate that many in-service teachers and teacher candidates will develop the competence and confidence to model GBL practices for their peers during year one. Therefore, the summer before the first year, we provided initial GBL professional development for five teachers who expressed the most interest in early implementation. Throughout the 2021-2022 academic year, we visited the schools to provide in-classroom support, and offered monthly workshops for all science teachers in the MCS middle schools. We continued to visit our participating teachers' classrooms and provide coaching on their curriculum and instructional practices throughout the year. While the first year has concluded, Phase 1 runs throughout both years.

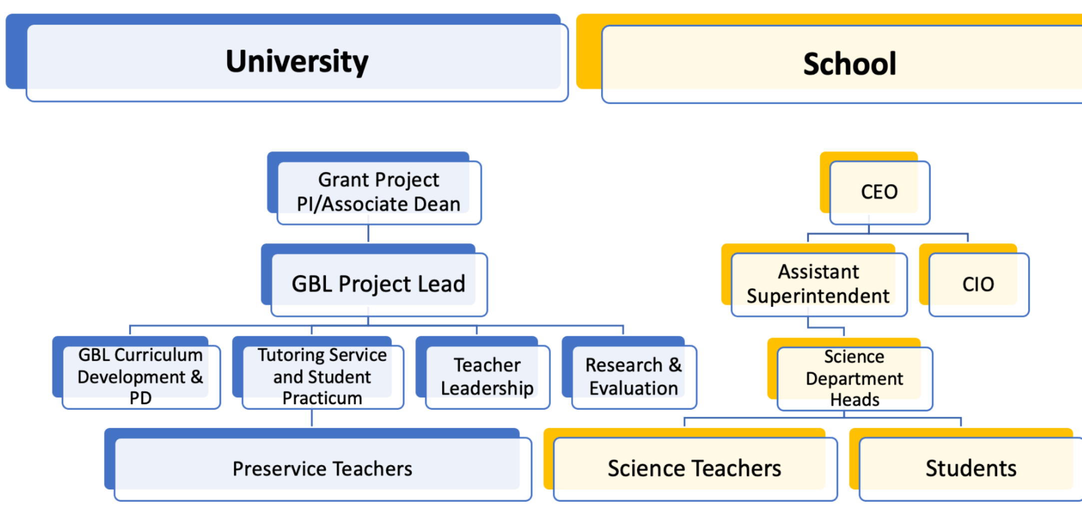
At the start of the 2022 school year, the goal of Phase 2 is to begin placing teacher candidate with GBL-participating in-service teachers. Pre-service teachers will observe our participating teachers' practices and interact with students for their own professional growth. In addition teacher candidates will offer tutoring services for struggling learners.

Finally, in Phase 3, the goal is to sustain teacher instructional practice and to support the reciprocal relationship with our partner schools after the grant is concluded. In order to sustain pedagogical or technological innovation within a community, teachers need to own and lead the effort themselves (Bradley-Levine et.al., 2010, 2017). Therefore, we are inviting teachers who participated in Year One implementation to serve as project leaders. We will provide ongoing leadership development and continue to support them as they enhance their GBL competence. We anticipate this will increase teacher capacity within the district and will sustain the adoption of GBL across both middle schools beyond the life of the project. To ensure that both teacher candidates and in-service teachers benefit from the partnership, we will also develop our participating teachers' mentoring competence, ensuring that they can offer our teacher candidates adequate guidance during their clinical practice experiences. Phase 3 will start in the summer of 2022 (see Figure 1).

The Stakeholders

The grant program we received uses a community-based approach to accelerate student learning. As part of this larger grant project, we worked with various levels of leaders and stakeholders to form the school-university partnership. As such, the formation of the partnership required extensive and constant communication and coordination among various stakeholders. This section will briefly introduce the key stakeholders involved for making this partnership possible (see Figure 2).

Figure 2
Different Stakeholders Involved in the Formation of School-University Partnership



At the first level, our Associate Dean for Equity and Engagement, Dr. Kendra Lowery, serves as the Principal Investigator of the grant project and coordinates all endeavors and communications among the various community partners and university faculty. Meanwhile, Dr. Lee Ann Kwiatkowski, the CEO for Muncie Community Schools, oversees and helps connect university faculty with district leaders.

At the second level, the first author (Ding) serves as the Co-PI of the grant project and oversees and coordinates all the endeavors in the GBL project. With the second (DuBois) and fourth (Bradley-Levine) authors, she is also in charge of delivering ongoing GBL coaching support and PD for teachers. On the MCS side, Dr. Charles Reynolds, the Associate Superintendent, supports our collaboration by serving as liaison between our team and the science teachers. In addition, Dr. Tony Harvey, the Chief Information Officer, ensures that teachers, students and the project team have access to necessary GBL technological resources.

At the third level, the third (Shaver) and fifth (Siebert) authors are coordinating the tutoring program and teacher candidate clinical practice experiences. Bradley-Levine oversees teacher leadership development and supports program evaluation in collaboration with the sixth author (Giraldo-Garcia). All members of the project team work with the science department heads at the two MCS middle schools to coordinate details about the monthly professional development and research activities. With all of these different levels of leadership, each share an over-arching goal of supporting the middle school science teachers and their students, and our own teacher candidates.

Findings

Our project began in June 2021 and will end in June 2023. Thus far, we have successfully completed *Collaboration Point 1*and are continuing to implement *Collaboration Point 2 (See Table 2)*. In February 2022, we also began implementing *Collaboration Points 3 and 4.*

Table 2
Timeline for Collaboration Points

		Start Date	Status
Collaboration Point 1	Summer Teacher Professional Development	July 2021 July 2022	Completed Planned
Collaboration Point 2	Monthly Professional Development and Year-long Coaching	August 2021 August 2022	Completed Planned
Collaboration Point 3	Bringing Teacher Candidates as Tutors for Struggling Students	February 2022	On-Going
Collaboration Point 4	Pairing Teacher Candidates with Participating Teachers for Professional Growth	February 2022	On-Going
Collaboration Point 5	Teacher Leadership and Mentorship Competence Development	Fall 2021	On-Going

In this school-university partnership, each collaboration point involves different opportunities, successes and challenges. They also require coordination, communications, and strategic planning among different stakeholders. As our model reflects a rather top-down collaboration approach, listening to teachers' voices and constantly modifying professional development to address teachers' learning needs is highly important to us. In this following section, we will share the opportunities, successes and challenges for each collaboration point and how we worked with different stakeholders to overcome the obstacles.

Collaboration 1: Initial Summer Teacher GBL PD

Organizing the professional development and recruiting teachers to participate in the project was a crucial but challenging first step. When we knew we had received the grant and would partner with MCS, there was only one month of summer break remaining to plan and host the professional development. As explained earlier, this grant project consists of various components and involves stakeholders at different levels. One of the initial challenges for us was to streamline the communication channels and confirm the contacts at both the university and the district and schools for the various components of the project. To address this, the grant project P.I., Dr. Kendra Lowery, convened a whole-group meeting to provide an overview of the grant program and allowed us to introduce our part of the project (GBL) to our school and community partners. During the meeting, we confirmed that we would collaborate with MCS and focus on supporting science education. From there, the CEO of MCS connected Dr. Ai-Chu Ding (first author/ GBL project coordinator) with the MCS Associate Superintendent, Dr. Chuck Reynold, and they became the two main contacts for planning the summer professional development.

Dr. Reynold shared with Dr. Ding the science department's current professional development needs, the curricular package the district had adopted, and the school schedule. They discussed how the project team could help address the needs of the school and the science teachers, as well as how they could introduce science teachers to the GBL approach to support integration of GBL within their existing curricular resources. Pleased with the plan, Dr. Reynold permitted the project team to design the learning activities for a three-day summer professional development that was already planned and intended for curriculum mapping. He also facilitated the team's utilization of the monthly early-release days (two hours) that were already planned for science teachers at both middle schools. Drs. Reynold and Ding agreed that the project team would facilitate teachers' curriculum mapping and recruit teachers to participate in the project during the 3-day summer professional development and then offer the participating teachers an additional two-day professional development focusing on GBL. Our relationship and collaborative planning with Dr. Reynold, the Associate Superintendent, was a critical point leading to the success of the initial phase of this project.

However, knowing that teachers may resist top-down professional development or pedagogical innovations, Dr. Ding made sure that on the first day of the summer professional development she asked for input from teachers about their challenges and professional development needs. She also explained the benefits of GBL and how it aligned with their existing curricula. She assured the teachers that their participation was completely voluntary; but she believed the use of GBL would help address some of the instructional problems they had been experiencing with their students. Intrigued by the new approach and its potential benefits, all six teachers who participated in the initial three-day summer professional development registered for the additional two days of GBL summer professional development, as well as for the year-long coaching focused on designing and implementing GBL units in their classrooms.

The initial three-day summer professional development focused on teachers creating new curricular maps to reflect the adoption of new science kits for student use. This workshop also allowed the university team to assist teachers in finding game resources which reflected the learning objectives in each beginning science units. The second GBL professional development presented GBL theory. This workshop also provided different formats of GBL and explored teachers interest in using Scratch in their science units.

Collaboration 2: Monthly GBL PD and Year-Long Coaching

Another key piece of the collaboration with MCS is providing monthly professional development sessions with the science teachers of both middle schools. The professional development sessions take place one to two times per month, depending on the MCS schedule. GBL has different models and levels of integration depending on teachers' familiarity, technology competence, and pedagogical orientations. During the summer professional development, the project team realized that our coaching must be attuned to the teachers' comfort level instead of forcing a particular GBL model on teachers. Therefore, during the initial professional development sessions in September, we introduced the benefits of GBL and possible implementation approaches to MCS teachers, but we allowed teachers to freely determine the best ways to adopt GBL depending on teachers' interest and competence in using technological resources, as well as the content they were currently teaching. This allowed teachers' ownership over the timeline, curricular content, and mode in which GBL would be integrated in their classroom.

Doing so allowed MCS teachers to plan lesson units with GBL approaches and try them in their individual classrooms, especially teachers who participated in the summer professional development. However, teachers who did not participate in the summer professional development were still skeptical and hesitant about integrating GBL into their classroom after the initial professional development sessions in September due to limited understanding and planning time for GBL. After the first month of school, the project team decided to transition the professional development to a modeling approach, which focused on two goals: first, introducing modes of technology for GBL learning and gaming, and second, previewing resources that connected to teachers' curricula and learning objectives.

Teachers examined different modes of technology to facilitate GBL including: Oculus virtual reality headsets, games and programming with Scratch, Legends of Learning, BreakOut.edu activities, and other online simulations (e.g., PhET). Each mode was presented in different professional development sessions and the project team modeled the technology with teachers acting as if they were the students. Modeling allowed the project team to ensure the discussion and reflective components of the GBL activity were integrated within the activity. Discussion followed the activity, with the project team assessing the interest of each teacher in the technology presented and possible adaptations or additional support (via training or in-class during implementation) needed for use. Additional discussion through email occurred for further integration follow-up and support for specific needs, including the design of a Breakout.edu unit for a particular science topic.

During the first professional development in January, the project team modeled the BreakOut.edu game on the periodic table, which had been created the previous semester by the project team. Following the professional development, teachers who had been skeptical about integrating GBL became excited about trying GBL with their students. One sixth grade teacher immediately looked through previously created BreakOut.edu games to identify those that she could use to meet the learning objectives for an upcoming unit. She also started coordinating with Ding on student grouping plans, including the number of kits she would need, and the dates for game play. In another example, another sixth grade teacher initially felt overwhelmed by the idea of implementing a new and unfamiliar approach. However, after the modeling during one of the professional development sessions, he immediately logged into a BreakOut.edu account (provided by the project team for the workshop) and searched for games he could use when teaching an upcoming unit. A third teacher, who was two weeks away from starting a GBL unit on genetics, discussed the creation of a BreakOut.edu game focusing on the learning objectives for this unit with Dubois (second author). The teacher discussed tailoring the BreakOut game to focus specifically on using probability and the integration of additional math practices with the Punnett Squares topic as puzzles in the game. The decision to use modeling as the format of our monthly professional development became a critical moment that led to our success in maintaining this collaboration.

Furthermore, because teachers identified time as a constraint and the necessity to address the standards, the project team decided that it was important that we provide contextualized GBL resources and curriculum planning support. We used the content of the MCS curricular maps to locate GBL resources that corresponded with learning objectives identified by teachers for successive units of study in each grade (i.e., six, seven, and eight). During each professional development session, the project team shared with teachers a spreadsheet with GBL games and activities that were aligned to learning objectives from the curricular maps. Teachers then collaboratively explored the games with their colleagues who teach the same grade to brainstorm how they might be used for upcoming science units. Teachers discussed connections to content and possible pedagogical uses while the project team answered questions or located additional resources. The team continued to correspond with teachers through email to share even more games or activities connected to specific science topics or lesson objectives brought up during these discussions. MCS teachers reported that the curation of games that aligned with their learning objectives was one of the most beneficial outcomes of the professional development sessions.

Collaboration 3: Remedial Tutoring Service for Struggling Learners

The third collaboration activity was the creation of during- and after-school tutoring opportunities for middle school students primarily in the area of science. This was a logical extension of the GBL programming, which was instituted in these schools within science classrooms. Additionally, MCS students have demonstrated difficulty with science as reflected both in grades and on standardized exams. Therefore, science was selected as the first subject for tutoring, with the eventual goal of expanding tutoring to all subjects once the grant established capacity for the tutoring program.

As such, discussions were held with administrators at three school sites within the community. The main conduit with which planning occurred was with Dr. Chuck Reynold, the Associate Superintendent of Muncie Community Schools. The three building-level administrators were, in theory, able to voice their ideas and concerns for the tutoring program via Dr. Reynold and he, in turn, would serve as a sounding board and line of communication between the university and said building administrators. Dr. Reynold was able to announce plans for the tutoring, both the idea for its inception and timeline for implementation at weekly leadership meetings with building administrators. This meeting was a part of MCS' planning and administrative communication. Discussions with Dr. Reynold were held both over the phone, via email, and in-person if he happened to be in the building when the researchers visited one of the tutoring sites.

The three sites had different preferences for when they wanted tutoring to occur. MCS requested that tutoring be available during the school day, asking for tutors to arrive at set times so that students could be scheduled for one-on-one tutoring while they were already at school. This avoided the need for students to arrange rides to or from school and allowed them to utilize transportation provided by the district. Discussions were also had with administrators to offer tutoring on campus during the weekends, further giving students access to qualified tutors. With this blueprint in mind, the project team planned the tutoring program, recruited tutors, and trained them (which will be discussed in more detail in the next section, Collaboration 4). However, due to various factors (e.g., multiple leadership changes at school locations throughout the fall semester, the pandemic-related issues with staff and student absences, and issues with the IRB), the tutoring program occurred for only a few weeks before the fall semester ended.

There were different issues with the program from its inception. It was discussed that the first round of tutoring would serve as a pilot to determine what aspects of the tutoring program should be implemented, what training we should give to tutors, how best to recruit future tutors from university pre-service teaching programs, and how our pre-service teachers would integrate into the various MCS spaces as tutors of science students. This pilot would span the gap between Phase I and Phase II until the tutoring program was fully established.

However, challenges arose emerging from a multitude of issues throughout the semester. Foremost, there was a breakdown in communication between Dr. Reynold and building-level administrators. At times, sites were unaware of the tutoring program with the university and turned away tutors. This most likely was a result of one of the tutoring sites having four different principals during the Fall 2021 semester. It is understandable, with that level of turn-over, that communication could be an issue between the new principals and the university attempting to establish the tutoring program. Additionally, COVID-19 continued to be a massive complication, leading to a large number of staff and students at all three locations missing time, further exacerbating the communication problems. Finally, issues arose with finalizing the IRB for the tutoring program, delaying the start of tutor recruitment and training until early November. As a result of these multifarious issues, we decided to continue with attempting to establish the pilot for the few remaining weeks in the semester until we were better able to meet the goals of Phase II with a fully operational tutoring program. While tutors were ready for the final few weeks, the MCS sites did not have any tutoring due to administrators not fully knowing when tutoring was to start and no locations for the tutoring to occur established in the schools.

Between the end of fall semester and the first few weeks of spring semester, we worked to find ways to overcome these obstacles. After discussing these issues and realizing some of the pitfalls and how they could be avoided in the future, we approached Dr. Reynold and discussed our idea for the future of the tutoring program. Moving forward into the spring semester, communication began with Dr. Reynold but then building-level administrators were contacted directly by the faculty member spearheading the tutoring component of the GBL initiative. This added layer of communication helped mitigate the aforementioned miscommunication issues. Additionally, tutor recruitment began before the start of the semester, giving pre-service teachers a chance to join the tutoring program before finding other employment at the university or in the community. Finally, as tutor numbers waned, we expanded tutoring positions from only pre-service science teachers to students majoring in science sooner, allowing for a faster training and orientation period and facilitating preparing tutors for the field faster. As a result, the partnership agreed to follow the same blueprint when the university and schools returned from summer break to establish a true pilot tutoring program, fully moving the partnership into Phase II in this regard.

Collaboration 4: Pre-service Teachers and the Practicum Experience

The tutoring program connected closely to one of the university's teacher education goals, which is to provide pre-service teachers continual, authentic teaching experiences during their four years of teacher training. As per Ball State University Teachers College's mission statement, this would continue to "prepare tomorrow's teachers and enhance the skills of current educators" under our instruction and care (Ball State University, 2022). Until Fall 2021, most secondary pre-service teachers only had one opportunity to work with students in the field for eight weeks during their middle school/high school practicum courses. As a result, graduates of the secondary teacher education program reported in exit surveys that they felt unprepared for student teaching and expressed a need to have more time teaching and working with students in the field before the pivotal and high-stakes student teaching semester. This assumed even greater significance since the aforementioned eight-week practicum did not typically occur until the semester before student teaching.

The GBL tutoring project represents one approach to achieve a "clinically-rich" teacher preparation program (American Association of Colleges for Teacher Education, 2018; Association of Teacher Educators, 2016; National Council of Accreditation to Teacher Education, 2010), allowing them to interact with middle and high school students in strategically-focused and developmentally-appropriate activities at the early stage of teacher preparation. The tutoring program drew from teacher education candidates in good standing enrolled in the middle school or high school practicum courses or multicultural education course. Tutoring positions were offered first to students who were preparing to become science teachers. After the first round of recruiting, the positions were opened to all secondary preservice teachers in good standing.

Tutors were offered a paid tutoring position and underwent a one-week orientation in which they completed an online tutoring module adapted from the Ball State University Learning Center's Peer Tutoring program for university students employed to provide tutoring services to other university students. The Learning Center's Peer Tutoring training drew on material from a number of well-established and highly-respected tutoring programs at other institutions as well as integrating videos, material, and activities created by Learning Center staff and experienced tutors. As the Learning Center provides assistance in all content taught at Ball State, the training focuses more holistically on providing tutors with pedagogical strategies and skills rather than content knowledge. Since the preservice teachers employed as tutors within this project came with content knowledge, but were fairly early in their professional education sequence, utilizing this comprehensive training model provided a solid introduction into the ways in which the knowledge, skills and dispositions of a tutor did (and did not) align with those of a classroom teacher. Once their training was complete, the tutors were assigned to one of the middle schools based on their availability.

Our efforts to support pre-service teacher education is ongoing and constantly evolving depending on the opportunities and needs we observe. Our Year One experience has taught us a great deal about the nature of this collaboration and helped us refine our plan to address the various aspects of tutoring programs, such as recruiting and placement. As we gradually iron out the administrative details of the program, we continue to revise our model of collaboration with our pre-service and in-service teachers to provide quality and in-demand professional learning opportunities for them. In terms of pre-service teacher practicum, our experience tells us that the field experience piece of the pre-service teacher education sequence is unique for expanding this program. Ball State University and MCS have had an extended partnership going back decades in terms of placements for both these field experiences and student teaching; in fact, current teachers participating in the GBL training have had students for these experiences in the past. Both Shaver (third author) and Siebert (fifth author) are in charge of placing students for their field experiences for practicum. We will continue to refine our recruitment and placement plan and foster relationships with GLB participating teachers to send more students to these classrooms, allowing our pre-service teachers to refine their GBL and STEM skills.

Collaboration 5: Teacher Leadership and Mentorship Competence Development

The project team invited teachers to opt in to the initial summer professional development opportunity, which allowed the team to support these teachers to develop curriculum and instructional skills related to an existing interest. Although teachers began professional development with varying levels of comfort and expertise, the ongoing support provided by the team allowed them to integrate learning at their own pace. During implementation, the team arranged support structures at the individual and group levels to provide just-in-time personalized assistance and establish a community of learners. The support structures provided by the project team fostered confidence among the teachers to try new instructional strategies, learn from mistakes, and make their practice transparent to their colleagues. The continuous and ongoing relationship between the project team and the teachers allowed us to form a relationship of trust and a collaborative learning community. The positive relationship thus established was a critical factor leading to the successful recruitment of teacher leaders.

Several teachers emerged early as leaders within the initial implementation group. These teacher leaders took the initiative to integrate GBL into their lesson plans shortly after the summer professional development. In addition, they supported others in the group by sharing their successes and challenges. The project team interviewed these teachers at the end of the fall semester. During the interviews, we asked them to reflect on how they had already shared their GBL work with their colleagues. We also probed their willingness to take on a leadership role in scaling up the project and joining in the work of encouraging and supporting other teachers in the middle schools to integrate GBL into their instruction. We then invited the teachers who described an interest in taking more responsibility to engage as co-designers and presenters for the next professional development. to be offered in Summer 2022. These teachers expressed enthusiasm and self-assurance, as well as a willingness to develop their leadership capacity with the project team.

As we prepare for the next professional development event, the project team will provide the teacher leaders with leader development opportunities so that they may replace the project team in providing necessary supports to their colleagues and our pre-service teachers in the coming year. For example, the project team will guide teacher leaders through a process designed in the United Kingdom and used by teachers participating in a national teacher leadership network. This process, called Teacher-Led Development Work (Frost & Durrant, 2003), provides a framework for teacher leaders to reflect on their values and concerns related to taking initiative to implement change across a school, identify their leadership capacity, and plan strategies to extend existing capacity. Teacher leaders then collaborate to create an action plan for implementing a specific change. In our case, the action plan will define the strategies and steps involved in scaling up the implementation of GBL across the two middle schools. During the second year of the project, our teacher leaders will carry out the action plan through ongoing collaboration with their colleagues and administrators. Some strategies they will use to manage the change include leading staff professional development experiences, modeling and sharing their own use of GBL with other teachers (including pre-service teachers), and mentoring and coaching their colleagues and our pre-service teachers during implementation. The teacher leaders will also gather and use data in order to evaluate and adjust the action plan. In addition, as these teacher leaders will serve as mentor teachers to our pre-service teachers, we will embed professional development focusing on mentoring strategies to foster their mentoring competence. As the program expands and more teachers join us to serve as mentors to our pre-service teachers, the teacher leaders will serve as mentoring coaches to support their colleagues' mentoring work, ensuring quality professional learning for both in-service teachers and pre-service teachers.

Participating Teachers Share Their Experience with the School-University Partnership

As our project is moving toward Phase 2, participating teachers have shared positive feedback about their experience within this partnership. They have also noted how the use of GBL has improved students' content learning and motivation. One teacher, the science department chair at one of the middle schools, wrote an email to her colleagues and to the MCS leadership team to share her experience trying one of the GBL resources we introduced:

> I just want to brag about my students and their continued hard work. . . . They have persevered through virtual reality, posters, greenhouse work, flipgrid videos, in-class games and now for my latest brag: BREAKOUT EDU! I have students emailing me asking [me] to help them solve the first lock. It's not even an assignment! I had 100% engagement in class and the students are excited to have a competition to see who will win. . . . Finally I have found a program that holds their attention and they WANT to solve the puzzles. I wanted to give a huge shout out to Ai-Chu and to Chuck for supporting our Science department. Thank you so much!

This teacher's enthusiasm is linked directly to her students' interest in learning science concepts because they are learning them through an engaging GBL activity. Another teacher, who teaches 8th grade, shared during an interview about the exciting improvement of her students' science performance:

> I kind of looked at the data on the pre- and post-test, and I saw there is like [a] 22% increase on knowing the different elements and things like that. . . . The biggest one I saw and was surprised to see was their short-answer responses. . . . I thought they would have done better with the multiple choice ones, but they actually did better with the short-answer responses than they did with the multiple choice. They had like anywhere from [an] 18 to 40% increase on writing information in on those short-answer responses. . . . I was kind of really surprised. . . . and I was impressed by that.

This teacher noticed that her students had more to write about the content they were learning than in the past. This seems to indicate that students attained a deeper level of learning and may have remembered more of what they learned as a result of GBL learning activities.

As shown through early data collection, the middle school science teachers who participated in the GBL project during Phase One have noticed an improvement in both students' engagement and learning outcomes during the GBL units they implemented. Data collection will continue through the next phases as the project team collects and analyzes learner data. However, these preliminary findings provide encouraging evidence that the project team was able to leverage the school-university partnership to facilitate learning recovery within middle school science classrooms. As teachers witnessed improved engagement and learning outcomes among their students, they also gradually changed their attitudes and perceptions about using GBL as an instructional approach. This is the type of change we wish to see.

Concluding Thoughts

This study has described an ongoing school-university partnership that aims to support middle school science learning recovery through the provision of teacher professional development and leadership, remedial tutoring services, and teacher candidate education. Our project is a two-year program where we have only completed the first phase of our model and are continuously planning and implementing the various collaborative components in this project. Through describing the various stakeholders and our decision-making process throughout the collaboration points, we have shown the complex and intricate nature of such a partnership (NAPDS Essential 7 and 9). We have also foregrounded a key aspect of forming school-university partnership that is less explored and discussed in the literature. For practitioners who plan to form school-university partnership to support student learning, our model and experiences will provide some insights into the challenges they may face and the potential strategies they may use to cope with the challenges. Specifically, we delineated how we modified and negotiated our collaboration with teachers in a spirit more aligned with the tenets of Professional Development Schools as defined by the Holmes Group (1990) and the National Association of Professional Development Schools (2008, 2021) in a “top-down” model of collaboration (NAPDS Essential 3 and 7). Our model embraced a commitment to reflection through innovative pedagogies to engage in a continuous professional learning with all participants (NAPDS Essential 4).

One recurring theme across the various collaboration points is the importance to gradually shift and empower teachers. In our unique context, and in many cases of school-university collaborations, the project would unavoidably start with a rather “top-down” model where the administrative teams make decisions for teachers and students. In such circumstances, listening to teachers early on in the project allowed us to understand teacher needs, pedagogical philosophies and constraints, and we were therefore able to make further modifications to our professional development and collaboration model for increased teacher buy-in (NAPDS Essential 3, 4 and 9). By noticing the barriers and needs specific to each teacher’s required level of support and classroom barriers, the project team immediately revised the content and mode of professional development, adding more modeling elements to facilitate teachers’ reflection and discussion with peers. In a top-down collaboration model, teachers particularly need to feel that they have control of the process. Thus, constant reflection and open dialogue facilitate the collaboration with partners (teachers, university team, school community) in identifying specific curriculum topics, planning the class activities with appropriate games, and implementing the game-based interventions (NAPDS Essential 4). In addition, as shown by our model timeline (Figure 1), we envision a model where teachers gradually gain control over their learning. Starting with engaging in GBL PD provided by us, they then serve as role models for other colleagues and our pre-service teachers (NAPDS Essential 9). Then through empowering the teacher leaders, teachers will take full control over their own learning by co-designing the future professional development sessions with us and even leading those sessions (NAPDS Essential 9). To that end, our model and experience could be helpful for practitioners in similar contexts. The study has shed a light on how we could realize school-university partnership in a relatively traditional school-university collaboration through the use of various strategies and components.

In terms of teacher candidates’ professional education, we have embraced the need for clinical practice through tutoring which allows pre-service teachers to increase their ability in guiding students in the learning process in a GBL context (NAPDS Essential 2). This skill set underscores the importance of understanding student motivation and connection to science concepts. This highlights the connection of teacher GBL competency to tutoring skills (Nousiainen et.al., 2018). It also provides pre-service teachers the ability to observe practices of formal and informal assessment using digital games and provide evidence of GBL and related activities to student mastery of learning objectives. Furthermore, as it pertains to GBL, teacher candidates rarely have any chance to observe this type of practice in the field. It is therefore challenging for them to adopt and design such an approach for their own students as well. With this school-university partnership, we see the potential for creating a rare professional growth opportunity for pre-service teachers to observe GBL practices by trained in-service teachers (NAPDS Essential 2). Due to the progress of our project, we currently do not have enough data to share findings about teacher candidates' professional growth within this model. Findings and conclusions of the study currently focus on our endeavors toward supporting our partner schools which reflects five tenets of the NAPDS Revised Nine Essentials. Through intentional communication with both MCS administration and middle grade science teachers, we were able to build capacity through GBL pedagogy to impact student learning. As we move forward to the next stage of our project, we will shift our focus to monitor the professional growth of our teacher candidates and continue to explore how we could leverage the school-university partnership to support their professional growth and continue to engage in collaborative research.

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References

Al-Tarawneh, M. H. (2016). The effectiveness of educational games on scientific concepts acquisition in first grade students in science. *Journal of Education and Practice*, *7*(3), 31–37.

American Association of Colleges for Teacher Education. (2018). *A pivot towards clinical practice, its lexicon, and the renewal of educator preparation: A report of the AACTE Clinical Practice Commission.* https://aacte.org/resources/research-reports-and-briefs/clinical-practice-commission-report/

Association of Teacher Educators. (2016). *Standards for clinical and field experiences: A report from the ATE task force for field experiences. https://www.ate1.org/resources/Documents/Standards/Revised%20ATE%20Field%20Experience%20StandardsII.pdf*

Ball State University. (2022). About us. https://www.bsu.edu/academics/collegesanddepartments/teachers-college/about-us

Bradley-Levine, J., Berghoff, B., Seybold, J., Sever, R., Blackwell, S., & Smiley, A. (2010, April). What teachers and administrators "need to know" about project-based learning implementation. In *Annual Meeting of the American Educational Research Association. Denver, CO*.

Bradley-Levine, J., Romano, G., & Reichart, M. (2017). Teacher leaders' influence on teachers' perceptions of the teacher evaluation process. *International Studies in Educational Administration, 45*(1), 66-85.

Collins, M. (2014). The fallacy of top-down educational reform (Part one). https://www.forbes.com/sites/mikecollins/2014/11/12/the-fallacy-of-top-down-education-reform-part-one/?sh=2365537836f8

Delaware County, IN. (n.d.). History of Delaware County and Muncie, Indiana. https://www.co.delaware.in.us

De Loof, H., Struyf, A., Boeve-de Pauw, J., & Van Petegem, P. (2021). Teachers' motivating style and students' motivation and engagement in STEM: The relationship between three key educational concepts. *Research in Science Education*, *51*(1), 109-127.

Dori, Y. J., Avargil, S., Kohen, Z., & Saar, L. (2018). Context-based learning and metacognitive prompts for enhancing scientific text comprehension. *International Journal of Science Education*, *40*(10), 1198-1220.

Feder, T. (2022). The US is in dire need of STEM teachers. *Physics Today, 75*(3), 25-27. https://doi.org/10.1063/PT.3.4959

Foster, A., & Shah, M. (2015). The play curricular activity reflection discussion model for game-based learning. *Journal of Research on Technology in Education*, *47*(2), 71–88. https://doi.org/10.1080/15391523.2015.967551

Frost, D., & Durrant, J. (2003). *Teacher-led development work: Guidance and support*. London, United Kingdom: David Fulton Publishers.

Gee, J. P. (2006). Are video games good for learning? *Nordic Journal of Digital Literacy*, *1*(3), 172-183.

Holmes Group. (1990). *Tomorrow's schools*. East Lansing, MI: Author.

Hsieh, T. L. (2014). Motivation matters? The relationship among different types of learning motivation, engagement behaviors and learning outcomes of undergraduate students in Taiwan. *Higher Education*, *68*(3), 417–433. https://doi.org/10.1007/s10734-014-9720-6

Hussein, M. H., Ow, S. H., Cheong, L. S., & Thong, M.-K. (2019). A digital game-based learning method to improve students ' critical thinking skills in elementary science. *IEEE Access*, *7*, 96309–96318.

Indiana Department of Education. (2021). 1008 Student Learning Recovery Grant Program and Fund. https://www.in.gov/doe/grants/1008-grants/

Ingersoll, R, Merrill, L., & May, H. (2014). What are the effects of teacher education and preparation on beginning teacher attrition? *CPRE Research Reports.* https://repository.upenn.edu/cpre_researchreports/78,

Johnson, W. R. (1990). Inviting conversations: The Holmes Group and "Tomorrow's Schools". *American Educational Research Journal, 27*(4), 581-588.

Johnstone, A. H. (1991). Why is science difficult to learn? Things are seldom what they seem. *Journal of Computer Assisted Learning*, *7*, 75–83.

Law, V., & Chen, C. H. (2016). Promoting science learning in game-based learning with question prompts and feedback. *Computers and Education*, *103*, 134-143. https://doi.org/10.1016/j.compedu.2016.10.005

McConnell, J. R. (2017). A model for understanding teachers' intentions to remain in STEM education. *International Journal of STEM Education, 4*(1), 1-21.

National Association for Professional Development Schools. (2008). *What it means to be a professional development school* [Policy Statement]. Executive Council and Board of Directors.

National Association for Professional Development Schools (2021). *What it means to be a professional development school: The nine essentials* (2nd ed.). https://3atjfr1bmy981egf6x3utg20-wpengine.netdna-ssl.com/wp-content/uploads/2021/05/What-it-Means-to-be-a-PDS-Second-Edition-2021-Final.pdf

National Council for Accreditation of Teacher Education. (2010, November). *Transforming teacher education through clinical practice: A national strategy to prepare effective* *teachers*. Washington, DC: Blue Ribbon Panel on Clinical Preparation and Partnerships for Improved Student Learning.

National Science Board. (2016). *Science and Engineering Indicators Digest 2016*. https://www.nsf.gov/statistics/2016/nsb20161/#/

Nousiainen, T., Kangas, M., Rikala, J., & Vesisenaho, M. (2018). Teacher competencies in game-based pedagogy. *Teaching and Teacher Education*, *74*, 85-97.

Sutcher, L., Darling-Hammond, L., & Carver-Thomas, D. (2019). Understanding teacher shortages: An analysis of teacher supply and demand in the United States. *Education Policy Analysis Archives*, *27*(35). https://doi.org/10.14507/epaa.27.3696

Tzuo, P.-W., Ling, J., Yang, C.-H., & Chen, V. H.-H. (2012). Reconceptualizing pedagogical usability of and teachers' roles in computer game-based learning in school. *Educational Research and Reviews*, *7*(20), 419–429.

US Department of Education. (2022). Teacher Shortage Area Report. https://tsa.ed.gov/#/reports

Van Lancker, W., & Parolin, Z. (2020). COVID-19, school closures, and child poverty: a social crisis in the making. *The Lancet Public Health*, *5*(5), e243-e244.

Wentzel, K. R., & Miele, D. B. (2016). Handbook of motivation at school: Second edition. In *Handbook of Motivation at School: Second Edition*. https://doi.org/10.4324/9781315773384