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Project-Based Inquiry (PBI) Global during a Pandemic: A New Learning Ecology Perspective

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Abstract: Building on new learning ecology theory and situated in the COVID-19 pandemic context, a qualitative research design was used to examine student and teacher perspectives on Project-Based Inquiry (PBI) Global. Drawing on Problem-Based Learning (PBL) and Project-Based Learning (PjBL), PBI Global supports participants toward engaging in inquiry-to-action aligned with the UN Sustainable Development Goals (SDGs). Data sources for this study included transcripts from student and teacher focus groups conducted before, during, and after the PBI Global process. Three themes emerged (1) creating global awareness of water issues, (2) learning to collaborate in remote and hybrid contexts, and (3) enhancing self-efficacy through iterative learning. The discussion focuses on the affordances and challenges of engaging in PBL during non-voluntary online learning, as well as study limitations and directions for future research.

Keywords: problem-based learning; project-based learning; inquiry-based learning; COVID-19 pandemic; new learning ecology; qualitative research

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1. Introduction

Teachers and students were required to make major adjustments to teaching and learning during the COVID-19 pandemic. Schools had little notice in switching from in-person to fully remote or hybrid models, with teachers having very little time to prepare to teach their students in a new format [1,2]. Many teachers struggled to create meaningful remote and hybrid learning experiences for their students as they navigated their new teaching terrain [3,4]. The purpose of this study was to explore how a new ecological system for learning was created through the implementation of a grade-level Problem-Based Learning (PBL) inquiry process using the Project-Based Inquiry (PBI) Global model [5] with ninth-grade students in the United States during the pandemic.

1.1. Inquiry as Problem- and Project-Based Learning

One of the main aspects of PBL is the emphasis on complex, ill-structured problems [6–8]. These types of problems require students "to share their current knowledge, negotiate among alternative ideas, search for information, and construct principled arguments to support their proposed solutions" [7] (p. 298). With its origins in medical education in the 1960s, the first PBLs were focused on clinical disciplines, in which students engaged with problems that reflected the messy nature of practicing medicine [9]. PBL then spread to professional programs, such as engineering, and secondary education contexts [9,10].

Similarly, Project-Based Learning (PjBL) developed in the 1990s [11] and further evolved over the years through the work of Krajcik and colleagues in the context of middle and high school science classes [12,13]. Although PBL and PjBL were initially derived in different educational contexts, they are both grounded in constructivist and sociocultural

theories that emphasize Deweyan notions of inquiry, which underlie learning science research [14,15]. For a full discussion of PBL and PjBL, see *The Cambridge Handbook of the Learning Sciences* [16].

1.2. Project-Based Inquiry (PBI) Global

Drawing from PBL and PjBL with a sustainable development focus [17], PBI Global is a specific, collaborative inquiry-to-action process that focuses students' research and social action on one or more of the UN Sustainable Development Goals (SDGs) [18]. The PBI process was initially oriented toward student knowledge creation using newly available instructional tools. As PBI evolved with global educators and students, the inquiry process became more problem- and action-oriented [5,19].

PBI Global has five phases (see Figure 1) in which learners work together in small groups to investigate and develop solutions toward meeting the 2030 SDG targets. As teachers and students prepare for inquiry, attention must be given to activating and building students' background knowledge on PBI Global content (i.e., the SDGs) and the inquiry process itself [20]. Students then apply this knowledge as they ask a compelling question aligned with their specific SDG interests. These questions can be comparative, solution-oriented, and/or action-oriented and propel students to dig deeper into their SDG-aligned topic of interest [19]. Once student groups have a fairly well-defined question directing their inquiry, they gather and analyze digital and print sources, and sometimes engage in original data collection, related to their question. The information that students gather and analyze is then creatively synthesized into claims and evidence in written and visual forms [5,21]. Throughout the inquiry process, students engage in multiple feedback loops to critically evaluate and revise their research question, sources, findings, and learning products. Students then have the opportunity to communicate their products to a larger audience and take social action (i.e., share, publish, and act). For more detail regarding PBI Global design and implementation, see Spires [5] and Himes [21].

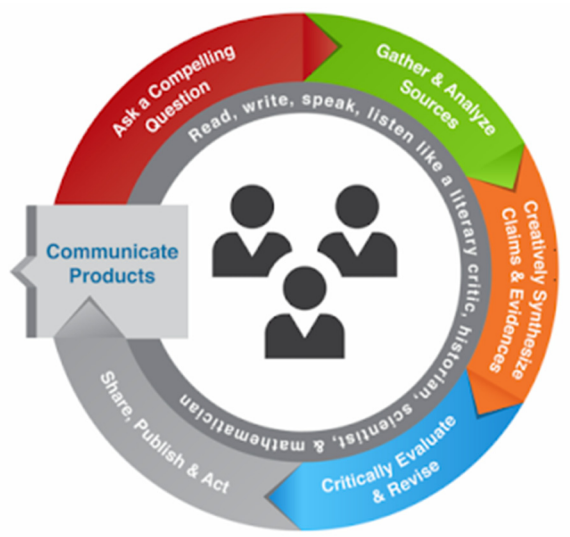

Figure 1. Project-based inquiry (PBI) global [5].

PBI Global has been implemented in a variety of instructional contexts, including US high school classrooms [20,22], and with global partners [5,19]. For this PBI Global, teachers and students collaborated to investigate topics pertaining to SDG 6: Clean Water and Sanitation and then shared findings virtually with their community.

2. Theoretical Stance and Research Questions

This study builds on earlier work from learning science grounded in constructivist [23,24] and sociocultural theories [25,26]. Learning ecologies are dynamic and undergo significant periodic, substantial shifts in response to societal innovations and phenomena. Within

this larger theoretical context, we call on the notion of learning ecologies to situate and articulate the classroom teaching and learning processes that specifically transpired within the COVID-19 pandemic. Knoblauch [27] suggested that PBjL and remote and hybrid learning equip teachers and students with generative ways to navigate the challenges inherent across contemporary learning contexts. We seek to examine PBI Global through the lens of learning ecologies as teaching and learning shifted during the pandemic.

Learning Ecologies

Kurt Lewin [28], and later Urie Bronfenbrenner [29], recognized the power of viewing education from an ecological perspective. Bronfenbrenner demonstrated that an individual's developmental outcomes are impacted by activities, policies, and events taking place within a larger social ecology. John Seeley Brown [30] defined learning ecology by drawing on the definition of ecology as "an open system, dynamic and interdependent, diverse, partially self-organizing, and adaptive" (p. 3). Barron [31] built on this perspective of learning ecology by contributing interest and self-sustained learning as catalysts for development. Spires [32,33] extended and adapted learning ecology theory to one-to-one computing contexts by defining the aspirational characteristics of a new learning ecology: (a) immediate and constant access to information; (b) intensity, relevance, and personalization of learning; (c) self-directed, curious, and creative learners; and (d) teacher as content expert, facilitator, consultant, mentor, and improvisationist.

After the theory was adapted to one-to-one computing contexts, Spires and Lee [34,35] conducted two studies that illustrated how the theory is applied within educational contexts. The first study [34] focused on the shifting dynamics and relationships that are required by teachers as they apply the new learning ecology of one-to-one computing within their classrooms. The purpose of the first study was twofold: (a) to use the new learning ecology as a theoretical lens to frame the dynamic changes and challenges that are introduced by one-to-one laptop computing initiatives and (b) to highlight the shifting dynamics and relationships in the new learning ecology that emerging research has shown to have implications for better preparing teachers and students to manage the change. The study identified specific changing relations at the school level, between the school and community, and between the school and pedagogy.

The second study [35] illustrated how new learning ecology theory was applied within the secondary classrooms of four teachers. The study utilized a multicase method approach with four high school core subject classes, including data from classroom observations, interviews, and teacher materials. The findings suggested that teachers searched for ways to situate one-to-one computing in their teaching through a variety of negotiated actions: (a) using digital technologies as learning tools, (b) supporting existing pedagogical strategies, and (c) establishing the computer as a hub for learning activities. Additionally, important consistencies regarding the nature of the learning ecology emerged in the classrooms. For example, immediate and constant access to information was the most prevalent condition. The students had Internet access and laptops; however, the four teachers leveraged that access in very different ways. The teachers were willing to facilitate their students' access to information even when that information included conflicting or even contradictory knowledge. The extent to which the teachers were willing to provide authority to students to regulate their learning was variable and influenced the ways in which the new learning ecology presented itself. These findings were foundational in creating a robust theoretical frame for one-to-one computing within a new learning ecology.

Since the development of the author's definition for [32,33] and application of [34,35] the new learning ecology in one-to-one educational settings, learning ecology theory has been studied, applied, and extended in a variety of technology-mediated learning contexts. For example, Ranieri et al. [36] explored educator learning ecologies in a blended professional learning program, while Wang et al. [37] proposed a Contribution-oriented Self-Directed Mobile Learning Ecology (CSDMLE) to support English as a Foreign Language (EFL) student vocabulary learning. However, the current study built on the author's [32,33]

conceptualization of a new learning ecology as it pertained to one-to-one educational settings during COVID-19 remote and hybrid learning, focusing on high school teachers and students during the pandemic. The following research questions were explored:

RQ 1: How did high school students and teachers implement PBI Global across remote and hybrid learning contexts during the pandemic?

RQ 2: How do characteristics of the new learning ecology manifest within the PBI Global process across remote and hybrid learning contexts?

3. Materials and Methods

3.1. Research Context and Participants

The study was conducted with ninth-grade students in a public high school in the southeastern United States. The school had a total of 188 students, including 54 students who identified as African American, 22 as Hispanic, 102 as White, 1 as Asian, 1 as American Indian/Alaskan native, and 8 as multiracial. The percentage of students who received free and reduced lunches was 37.20%, and 44.68% of the students were first-generation college-goers.

We worked with 27 ninth-grade students and 6 teachers (science, math (n = 2), English, social studies, and Spanish), a teaching assistant, and the principal to implement a PBI Global on the topic of global water and sanitation. Students collaborated in teams of three for a total of nine teams. Each team was assigned a teacher or teaching assistant who acted as their coach. Two teachers—the English and social studies teachers—coached two teams each. Project time was designated during each subject area class throughout a seven-week timeframe with additional collaborative teamwork sessions being held on Fridays during ninth-grade seminar and mid-week during curriculum assistance. For a full description of how content area instruction is integrated and interdisciplinary student learning is supported within PBI Global, see Himes [21].

Because the project took place during the COVID-19 pandemic (spring 2021), teachers and students worked across hybrid learning environments in which teachers were physically located at the school while students were either fully remote and online or operating on a hybrid schedule of in-person learning and remote, online learning during the project. In order to facilitate the PBI Global process online with remote and in-person students, teachers created a dedicated Google Classroom course site to centralize all pertinent, student-facing project materials. Additionally, to support hands-on learning regardless of students' physical location, the teachers curated a PBI Global box for each student; the box contained a common text, a water testing kit, materials to build a water filter, and introductory information on the project. The subsequent experiential tasks were conducted synchronously with students via Zoom.

3.2. Data Sources and Analysis

The qualitative data sources included verbatim transcripts from the audio recordings of student and teacher focus groups and student teams' final learning products (i.e., digital infographics and tri-fold displays). The researchers conducted two student focus groups (composed of six students each) at three intervals—before, during, and after the PBI Global process was implemented. Student participation in the focus groups was based on teacher recommendations and student interest. The teacher focus group (composed of six teachers) was conducted before and after PBI Global implementation. Each focus group lasted approximately one hour.

Following data collection and given the complexity of the data set, which included educator and student perspectives collected at project intervals, we chose a team approach to coding [38]. A team orientation to coding allows for analytic diversity and can, therefore, increase trustworthiness. It also necessitates methodological attentiveness to ensure "stability of responses" across all coders, and Creswell as cited in Ref. [38]. During phase one coding, authors four and five used ATLAS.ti to open-code [39] focus group transcripts. The research dyad independently conducted provisional coding of a purposive sample

of 25% of the entire data corpus. During the provisional coding process, authors four and five remained open to the discovery of new codes and wrote analytic memos. They met periodically to discuss new codes and to review and reconcile any differences in their coding [40]. Following two rounds of independent coding, authors four and five reached agreement, and author five coded all the remaining data. Authors four and five shared their results via analytic memos with authors one and two [41].

During the second phase of analysis, authors one and two applied a priori concept coding frameworks [42] to the results of the open coding based on the four characteristics of the new learning ecology [32,33]. Specifically, the research dyad used segments of discourse to identify connections between the data and new learning ecology characteristics. Authors one and two employed pattern coding to ask questions of the data, collapse codes, and develop emerging themes [42]. Ultimately, authors one and two identified four codes for theme 1, four codes for theme 2, and six codes for theme 3. See Table 1 for sample code book, including themes, codes, definitions, quotes, and new learning ecology theoretical connections. The sample codes included in Table 1 were the two most frequently identified codes within each theme.

Table 1. Sample code book.

	Themes	Sample Codes	Sample Definitions	Sample Quotes	New Learning Ecology Theoretical Connection
1.	Creating global awareness of water issues	Geopolitical context	Complexity, breadth, and depth of the global water crisis	"So just to think that already out of 7 billion people 1.8 billion people don't have access to adequate water and sanitation is crazy". (Student)	Immediate and constant access to information (characteristic a)
		Water quality knowledge	Technical know-how in testing and ensuring clean water	"What we did is we tested the standing water for pH and a bunch of other stuff for alkalinity". (Student)	Intensity, relevance, and personalization of learning (characteristic b)
2.	Learning to collaborate in remote and hybrid contexts	Reframing perspectives on collaboration	Developing understanding around what collaboration looks and feels like when learning online vs. face to face	"I'm sure they were forced to come out of their comfort zone. . .It wasn't as simple as sitting across the table from somebody in a group activity in a classroom". (Teacher)	Self-directed, curious, and creative learners (characteristic c)
		Challenges to collaborating online	Communication obstacles students face during collaborative online learning	"Working together is a little harder to do over text message". (Student)	Immediate and constant access to information (characteristic a)
3.	Enhancing self-efficacy through iterative learning	Inquiry as agency	Expressing breakthroughs in pedagogical thinking and applications	"It's changing the way I want to teach. I want to incorporate this kind of learning experience throughout my courses—a problem that really drives learning. PBI Global has helped me see what that might look like". (Teacher)	Teacher as content expert, facilitator, consultant, mentor, and improvisationist (characteristic d)
		Complex learning through chunking and authenticity	Acknowledging how big real-world ideas/tasks can be studied and addressed	"Even though these [the SDGs] might seem like big world problems, if you educate yourself enough and then use that power to educate others, you can eventually make a big impact". (Student)	Intensity, relevance, and personalization of learning (characteristic b)

4. Results

Three themes emerged from the student and teacher focus groups in response to our two research questions: (1) creating global awareness of water issues, (2) learning to collaborate in remote and hybrid contexts, and (3) enhancing self-efficacy through iterative learning. In addition to describing how high school students and teachers implemented PBI Global across remote and hybrid learning contexts during the pandemic, the four characteristics of new learning ecology theory [32,33] are embedded within and across our three themes.

4.1. Theme 1: Creating Global Awareness of Water Issues

Early in the project, it became clear that most students were not aware of the critical conditions surrounding global water and sanitation. As they began their inquiry process through the reading of informational and narrative texts on the subject combined with virtual interactions with external experts, they began to understand the gravity and relevance of these conditions. The students' immediate and constant access to information (new learning ecology characteristic a) during the project contributed to their increased awareness of the water crisis, as one student realized, "The total population is like 7 billion people. So just to think that already out of 7 billion people, 1.8 billion people don't have access to adequate water and sanitation is crazy".

During the PBI Global process, student awareness increased through learning by doing remotely. To participate in hands-on activities in their homes, students utilized the water testing and filter building kits from their PBI Global boxes, which enhanced the intensity, relevancy, and personalization of their learning (new learning ecology characteristic b). A student commented on the water testing and filter building activities:

> Basically, we went out and collected a water source from any kind of standing water [near our home], and then we worked together as a team [remotely] to develop and build filters from certain materials that we were given. We were given some sand, some fine coarse rocks, some activated charcoal, a cheesecloth, some coffee filters and two bottles.

The same student continued their description of water testing:

> What we did is we tested the standing water for pH and a bunch of other stuff for alkalinity. Then we built the filters and filtered it through three different times. And each time that we filtered it through, we tested all the levels again and then recorded the data.

Another student expressed how the self-directed activities (new learning ecology characteristic c) embedded in the PBI Global process, like building the water filter, contributed to a heightened sense of awareness and empowerment: "We learned more about the problems around the world, and how to solve them".

In short, some students gained awareness of how water and sanitation issues affect communities differently and felt empowered by coming together virtually with others to work toward meeting the Global Goals. Students' growing sense of awareness and empowerment were then leveraged during PBI Global to further the intensity, relevance, and personalization of their learning (new learning ecology characteristic b). For example, as a background knowledge building activity, students examined instances of communities experiencing water scarcity, water pollution, and inadequate water and sanitation infrastructure. When planning the social action piece of their PBI Global, students were intentional about taking action locally (i.e., collecting bottled water donations for the community food pantry), as well as globally (i.e., hosting a walk for water to raise funds for an international non-profit organization).

Students exhibited curiosity (new learning ecology characteristic c) about issues connected to global water and sanitation, specifically, in the creation of their compelling questions. For example, one student's compelling question examined global water and sanitation challenges through the lens of a second SDG, "tying agriculture (SDG 2) to water

quality and sanitation". They observed that this compelling question framing was "very informative and helpful" and even "awesome".

In addition to compelling questions igniting students' curiosity around global water and sanitation, each team's question served as a mechanism for personalized learning (new learning ecology characteristic b). One student noted that a peer's compelling question focused on "communities and [water] transportation" while her question focused on "how water can help with world hunger". In this way, students' inquiries took different directions based on their personal interests in global water and sanitation. This personalization of learning also amplified students' curiosity (new learning ecology characteristic c). As one student reflected, "it was interesting to see which person came up with what idea. . .All of them [students' compelling questions] . . .would have been really interesting to research".

Teachers observed that the explorations the students conducted with the water testing sparked their curiosity (new learning ecology characteristic c), which led to deeper connections to water-related science concepts. One teacher mentioned: "I think we did hit that science even harder, and I think it showed in the choices of what the students researched".

Interestingly, students' capacities for understanding the complexity, nuance, and universality of global water and sanitation varied. Students exhibited emerging understanding when they reflected: "I didn't realize that there were that many people who didn't have toilets and running water. It sucks that not everyone can have [clean] water". A common tendency once students become aware of global water issues is to want to "help and do a lot more". This presented opportunities for teachers to act as facilitators (new learning ecology characteristic d) in support of student reflection and development of critical perspectives on how these challenges manifest not only in global communities but also in their local context. One student spoke to the value of "getting different people's inputs from different communities and areas. . .because we all think differently and have different experiences". Thus, growth in students' global awareness of water issues necessitates a cyclical process of learning and reflection facilitated by improvisationist teachers (new learning ecology characteristic d) aiming to enhance the relevancy, intensity, and personalization of students' learning (new learning ecology characteristic b).

4.2. Theme 2: Learning to Collaborate in Remote and Hybrid Contexts

In line with the new learning ecology's one-to-one setting, Information and Communication Technologies (ICTs) were essential to student and teacher collaboration during this PBL; however, since these technologies were utilized in remote and hybrid learning environments rather than in face-to-face settings, teachers felt heightened concern regarding student motivation and engagement as the physical distance from students complexified teachers' roles as content experts, facilitators, consultants, mentors, and improvisationists (new learning ecology characteristic d). As one teacher affirmed, "The COVID-19 hybrid model for school was the biggest challenge to student motivation, teamwork, and collaboration". A colleague expanded on this notion sharing, when learning is reliant on students connecting via computers, "it's much easier to ghost your screen and play your video game and pretend you're listening". One teacher emphasized the value of face-to-face learning observing, "As much as I support online learning, and as much as I know that we are moving in that direction, there's no replacing the ability to physically stand beside a student and say how can I help you". The hybrid and remote learning environments challenged teachers in this PBI Global to act as improvisationists, re-imagining their roles as facilitators, consultants, and mentors (new learning ecology characteristic d) when they could not regularly share physical classroom space with students.

Collaborating within a PBL approach, like PBI Global, across remote and hybrid learning environments highlighted assets and challenges for students, as well. One student commented on the advantages of collaborating face to face versus virtually:

> It's really easy to learn about somebody's personality when you're put into an environment where you have to work together—where you normally wouldn't [or can't] talk to people. [Working face-to-face] you get to see every aspect

> of them—how they react under pressure, how they react when asked to do something.

In this way, working remotely with peers impacted students' learning ecology. In particular, the nature of self-directed (new learning ecology characteristic c) learning shifted as students developed new approaches to observing and analyzing their interpersonal and academic interactions with peers from afar and then adjusting their behaviors accordingly.

Although students had immediate and constant access to ICTs (new learning ecology characteristic a) throughout the project even when learning remotely, student participants underscored that access was not always synonymous with synchronous use. As one student highlighted, "sometimes everybody would drift off and do their own thing instead of discussing together". The school site for this study, like many others during COVID-19 remote and hybrid learning, had to balance academic learning and students' overall well-being, particularly concerns over having students on video conferencing platforms for up to eight hours every day. A student emphasized that collaborating is "a little harder to do over text message". Thus, the students' collaborative PBL work was sometimes characterized by one-way and interrupted communication. In this way, the efficacy of students' collaboration was impacted not only by immediate and constant access to information through ICTs (new learning ecology characteristic a) but also by not always having dedicated time and shared physical or virtual space.

4.3. Theme 3: Enhancing Self-Efficacy through Iterative Learning

Aligned with Bandura's [43–45] conceptualization of self-efficacy, teachers' confidence in their capacity to effectively carry out the roles of content expert, facilitator, consultant, mentor, and improvisationist (new learning ecology characteristic d) during PBI Global developed through the iterative process of facilitating multiple PBI Globals over time. The teachers involved in this PBI Global were facilitating the project with students for the third time. Despite changes in how the educators implemented PBI Global from past years (i.e., remote and hybrid formats with first-year students collaborating within their own school), the teachers felt prepared to navigate this landscape sharing, "we have the experience of [teaching] online that we didn't have last year. . .and working with students who are already comfortable with their peers".

The role of the teacher as a facilitator and improvisationist (new learning ecology characteristic d) was evident as teachers' self-efficacy grew through the remote implementation of contingent scaffolds—in-the-moment guidance and supports from teachers based on immediate student needs. For example, during an online book discussion, one teacher recognized that some students were viewing global water and sanitation challenges as a problem prevalent outside the United States. Therefore, the teacher guided students in "making connections, especially from our driving text, to local applications". This teacher also described how their attitude toward engaging in inquiry learning evolved: "Our comfortability has increased. Now we're fully vested in it [PBI Global]". A colleague concurred:

> It's changing the way I want to teach. I want to incorporate this kind of learning experience throughout my courses—a problem that really drives learning. PBI Global has helped me see what that might look like.

Through the opportunity of iteratively designing and implementing PBI Global across multiple years, teachers expressed self-efficacy through the lens of continuous improvement. For example, one teacher reflected that during the current PBI Global they were already thinking about "the next iteration of this project. . .and maybe as a focus we should spend more time supporting students to analyze data". Thus, iteration served as reinforcement for teachers' self-efficacy; it shifted their focus from the ideal design and implementation of PBI Global toward reflection and continuous improvement with an eye toward relevancy and personalization of learning (new learning ecology characteristic b).

In terms of enhancing student self-efficacy, an integral part of students' engagement in PBI Global was to "critically evaluate and revise" their work based on adult and peer

feedback [5]. The feedback loops during this PBI Global prompted one student to "rethink things a lot" and "stay focused. . .so that I knew exactly what I needed to do to get stuff done". Another student mentioned that feedback on their digital products helped make them "a whole lot more professionally written" and how that feedback, in turn, made the student pay more attention to "word choice and usage in other people's articles". Thus, students' self-efficacy throughout the inquiry process was connected to iteration and feedback loops that supported their capacity for self-directed learning (new learning ecology characteristic c).

A student, also, noted how feedback loops and iteration during the inquiry process enhanced their self-efficacy ahead of the virtual showcase: "I'm building my confidence and getting over some stage fright". One student reflected on the potential outcomes of enhanced self-efficacy through PBI Global, asserting "even though these [the SDGs] might seem like big world problems, if you educate yourself enough and then use that power to educate others, you can eventually make a big impact". As with the teachers, orienting students throughout PBI Global toward iterative learning enhanced their self-efficacy by emphasizing personalization (new learning ecology characteristic b) and continuous growth in breadth and depth of knowledge. Students' self-efficacy was further amplified through being empowered as self-directed, curious, and creative learners (new learning ecology characteristic c) to share their knowledge with others.

5. Discussion

The results of this study add to a growing body of research on how remote and hybrid learning during the COVID-19 pandemic transpired [2,46,47]. Specifically, this study provided insight into how teachers and students persevered during a crisis to sustain learning through PBL and how learning ecologies may evolve out of necessity to meet student needs. The discussion is organized by addressing (1) the affordances and limitations of engaging in a PBL process, like PBI Global, for students and teachers during non-voluntary online learning; (2) the limitations of the study; and (3) the implications of the study for future research and conclusion.

5.1. Affordances and Challenges of Engaging in a PBL Process during Non-Voluntary Online Learning

With regard to affordances, engaging in PBL through remote and hybrid learning environments provided a means by which students and teachers could have immediate and constant access to information and each other. Learning online decentered teachers as the primary purveyors of information to students; teachers leaned into their roles as facilitators of learning, affording students the opportunity to find and evaluate varied information sources (e.g., scholarly articles, media reports, and open-access data) via the Internet.

Moreover, by designing the PBL experience to be collaborative, the teachers created the expectation for themselves and students that teaching and learning together would be the norm. In this way, teachers prioritized human connections despite students' and teachers' physical distance from one another. Additionally, the COVID-19 pandemic and non-voluntary online learning created the conditions to more readily connect students and teachers with experts beyond their immediate school community through ICTs. Students' and teachers' flexibility, familiarity, and comfort with communications technology, such as Zoom, Google Meet, Padlet, and Flipgrid, grew, thus, increasing the potential in frequency and volume of collaboration and connection beyond school walls.

The most prominent challenge of non-voluntary online learning, as expressed by teachers and students in this study, is that immediacy and continuity of access to information and each other did not always translate into effective learning. Teachers and students cited challenges in maintaining connections via remote communication channels. As one student noted earlier, "sometimes everybody would drift off and do their own thing instead of discussing together". In a physical classroom setting, when students become distracted or wander off-task, teacher–student proximity usually allows for redirection; however, in an

online learning environment, it can be challenging for students and teachers to co-construct communication when it is unclear what is being received and acted upon.

5.2. Limitations of This Study

As a qualitative study focused on the PBL experiences of teachers and students in one southeastern US high school during the COVID-19 pandemic, the findings of this study are not generalizable. Moreover, authors one, two, three, and four served dual purpose roles within the study as researchers and PBL coaches for the teachers; thus, the candor of teacher and student responses during focus groups may have been impacted. The researchers attempted to mitigate these limitations through study design features, i.e., focus groups that included all teachers at the school study site and students across multiple PBI Global teams, data collection led by authors four and five who had more limited pre-existing relationships with the teacher participants, and conducting focus groups at three points throughout the course of the study, in order to gather authentic perspectives from a diverse group of PBL participants.

5.3. Implications for Future Research and Conclusion

The multifaceted nature of this period of remote and hybrid learning necessitates updates in application to new learning ecology theory, specifically with regard to teaching and learning in a one-to-one environment in which students and teachers are not occupying shared physical space. Both the teacher and student participants in this study raised concerns about student motivation and engagement in a non-voluntary online learning environment. And, although we hope the need for long-lasting, non-voluntary online learning does not arise again, educators, students, policymakers, and caregivers could benefit from research that identifies and contextualizes best practices for teaching and learning with regard to student motivation and engagement in these types of scenarios.

This PBI Global project sought to prepare "young people and adults to imagine and create a more just and sustainable society" during an unprecedented period for our global community [48] (p. 1). One student underscored the importance of engaging in learning that is inquiry- and action-oriented asserting, "If you educate yourself enough and then use that power to educate others, you can eventually make a big enough impact". This student's aspirational insight reminds us of the importance of viewing education as transformation. Thus, deepening and complexifying our collective understanding of how PBL may be a fulcrum for this transformation across learning contexts—online, remote, and face to face—is important, and new learning ecology theory serves as one lens through which to analyze this pedagogical approach.

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