KENAN FELLOWS PROGRAM FOR TEACHER LEADERSHIP NC STATE

*Journal of Interdisciplinary Teacher Leadership* 2023, Vol. 7, No. 1, pp. 28-72

# Outcomes of District-Led Professional Development Embedded within Biology Professional Learning Communities Among Three High Schools in a Single School District

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## Abstract

District-led Professional Development (DLPD) holds great promise for cost-effective and sustained PD for K-12 faculty but is often enacted as whole-group, one-shot meetings on topics (e.g., 21st-century learning) non-specific to teachers' grade levels and content areas. Alternatively, Professional Learning Communities (PLCs) provide on-site and ongoing collaborative support to teachers by common grade levels or content areas. To best leverage DLPD and PLCs, an exploratory multiple case study was conducted to examine how three separate high schools' biology PLCs had received and enacted DLPD in teaching 21st-century skills. Desimone and Pak's five core features of effective PD were used as the theoretical framework to explore teachers' perceptions of the semester-long DLPD through interviews, lesson plans, PLC agendas, and classroom observations. Case analyses found that participating biology teachers perceived that the *coherence* and *content focus* was the greatest affordances of having 21st century focused DLPD in their PLC. *Collective participation*, *active learning,* and *duration* were revealed respectively. Results suggested teachers had incorporated the 21st-century skill of *communication* the most and *creativity* the least in their practice. Findings suggest that DLPD embedded within PLCs provide contextualized PD opportunities to high school biology teachers when there is sufficient time and opportunities for translating knowledge into practice.

As professional learning communities (PLCs) have become more common across K-12 schools, it is important to understand how they provide the development and personal growth of K-12 teachers. Teachers, especially teachers of science, desire in-service or job-embedded professional development (PD) experiences to stay abreast of best practices in science education (Zhang et al., 2015). Historically, science teachers have attended conferences and workshops of their own accord to acquire knowledge of science content, new curriculum, and instructional (herein C&I) strategies, and collaborate with fellow teachers (Noonan, 2019). However, prohibitive costs (e.g., travel, and substitute teachers) have stymied teachers' abilities to engage in varying forms of professional development (Wong et al., 2022). Further, should science teachers wish to garner skills in an area outside of yet related to science (e.g., 21st-century skills), those opportunities are fewer (Mthanti & Msiza, 2023). One modality for PD that holds great promise for low-cost sustained PD, yet has yielded mixed to poor results, is PD experiences sourced from and delivered by the school district (Hill, 2009) as "each year[,] school districts invest financial resources in professional development for their educators…too often the return on this investment is minimal in learning transfer for educators or measurable academic gains for students and maximum in participant dissatisfaction." (Germuth, 2018, p. 77).

Yet, district-led PD (herein DLPD) has the potential to provide a consistent and sustained in-service PD experience for teachers by providing vetted and embedded support for teachers throughout the school year. By leveraging economies of scale, DLPD could serve as a cost-effective and time-efficient means to provide targeted, consistent, and sustainable (collectively known as *effective*) PD opportunities to teachers. Further, with PD coming from within their district, PLCs may feel less isolated in their work and united towards a common goal (Sperandio & Kong, 2018). DLPD occurring during PLCs may establish a collaborative space and provide the necessary time for teachers to learn and apply new knowledge with their colleagues (Jäppinen et al., 2016), so teachers may implement novel research-based strategies individually with their group (PLC) and the district's guidance and support. However, for DLPD in PLCs to be effective in changing C&I classroom practices, participating secondary science teachers must perceive that the DLPD is effective (McCray, 2018). Hence, the PLC must be 1) consistent, 2) collaborative, and 3) helpful, the three factors that describe effective PD, to change their teaching practices (Jones et al., 2013).

For teachers to effectively teach science, PD experiences must be aligned with teachers' professional goals (Hill, 2009; Kent, 2004). Frequently, though, DLPD is purposefully made for a general teaching audience and is often agnostic to the grade level or subject area (Darling-Hammond et al., 2009). For district PD to be effective, the PD should focus on a common element, important to teaching and learning in school. One such element is *21st century skills*, defined and operationalized in this study as the '4Cs' of critical thinking, creativity, collaboration, and communication; these are needed skills for students to build upon and convey their subject-area knowledge (National Education Association [NEA], 2012; Partnership for 21st Century Learning [P21], 2015). The 4Cs are particularly important in improving students' knowledge (Hiong & Osman, 2013) and motivation (Ahmad & Ismail, 2023) in biology, but also better convey to students why science is relevant, how to solve problems through inquiry, and to communicate their knowledge to others (Saavedra & Opfer, 2012; Sukarso et al., 2019). Given the dearth of science-focused PD related to disciplinary teaching for 21st-century skills (Maass

& Engeln, 2019; Shidiq & Yamtinah, 2019), DLPD in PLCs may be able to provide biology teachers with sustained and district-vetted collaboration and support (Horton & Martin, 2013) to acquire and integrate 21st-century skills into their teaching.

## Elements and Importance of Effective Professional Development

Teachers in the U.S. spend more time teaching students when compared to their international peers and have fewer opportunities to plan high-quality lessons (Darling-Hammond et al., 2009). Therefore, job-embedded PD must be perceived by U.S. teachers as relevant, interactive, and delivered by people who understand teachers' experiences (Boston Consulting Group, 2014). Research suggests PD can be perceived as valuable by teachers when there is a clearly defined purpose (Darling-Hammond et al., 2017) and they can envision how to translate PD learning to the classroom (Jeanpierre et al., 2005), yet PD to practice requires multiple opportunities to learn knowledge of the domain and discuss the domain's practices with other teachers engaged in those practices, experiment in the classroom with repeated teacher-learner interactions to build efficacy in the new practices and receive feedback on said practices (Dunst & Raab, 2010). Whitworth and Chiu (2015, p. 132) have said for science teachers, effective PD develops both teachers' content knowledge *and* pedagogy, acknowledging that knowledge and skills are equally "crucial component[s] to improving science education." Related research by van Driel et al. (2012) echoed the importance of effective PD for science teachers that support their development of content knowledge; the authors advocated for the use of salient, transferable, and applicable instructional strategies during PD. This research collectively suggests that teachers' perceptions of the effectiveness of PD are paramount in translating the PD to classroom practices.

## Theoretical Framework

The present study was based upon research by Desimone and Pak (2017) of the five critical features (constructs) of effective PD. This framework reflects the previously reviewed scholarship by integrating five critical elements of effective PD, which is: 1) content focused, 2) uses active learning strategies, 3) has a clear coherence to practice, 4) is of a sustained or prolonged duration, and 5) leverages collective participation among PD participants. The model operationalizes how effective PD can manifest into learned practices in the classroom. Coupled with the notion that PLCs hold a great potential for teacher professional learning (van den Boom-Muilenburg et al., 2021), the Desimone and Pak (2017) framework allows us to explore, through high school biology teachers' perceptions, the extent that DLPD on 21st century learning in PLCs was effective in their learning and how their learning manifested into their classroom practices. We can qualify classroom implementation using a continuum of use in classroom practice, from emerging, developing, approaching, to proficient (Texas Education Agency [TEA], 2016).

The Desimone and Pak (2017) framework is predicated upon the importance of peer-based coaching in teacher PD, a theory of action that is part and parcel of PLCs (Coburn & Russell 2008). To illustrate this connection, we describe six examples of how PLCs relate to the framework in providing elements of effective peer-to-peer PD. First, PLCs provide opportunities for teachers in common content areas to work together for instructional planning, learn through mentoring and peer coaching, and collectively guide curriculum and assessment decisions (Darling-Hammond et al., 2009), which are vital to retaining teachers of science (Hutchison, 2012). Second, PLCs provide a collaborative cultural space to promote a change in teacher practices through sharing ideas of active learning strategies (Desimone & Pak, 2017). Third, PLCs operate as a process to allow teachers to problem-solve through collaborative inquiry and action research to foster learning for their students (DuFour et al., 2016). Fourth, PLCs provide consistency to PD and practice within a common focus (grade, subject), and fifth, PLCs can meet regularly (depending on the school district and PLC model selected) and can last for years (DuFour et al., 2016), promoting continuous improvement among its members (Stoll et al., 2006). Last, but not least, the PLC process allows teachers to participate in shared decision-making by engaging in collaborative work and joint responsibility for the outcomes of their work (Harris & Jones, 2010), such as shared vision, mission, and goals, of a district (DuFour et al., 2016). In the present study, the shared district goal was to improve students' acquisition of 21st-century skills and use the PLC time biology teachers have (as seen in Table 1) to engage in DLPD focused on 21st-century skills. From observations of those interactions, their personal interview feedback, and classroom observations, may use the framework to explore teachers' perceptions of effectiveness from participation in DLPD within PLCs. Also, the framework can help us understand the manifestations of teachers' learning of the PD (21st-century learning) within their classroom practices (Desimone, 2009; Desimone & Pak, 2017).

## Conceptual Framework

Science teachers who participate in PD that leverages collaborative relationships with their peers produce positive outcomes for both participating teachers and their students (Lakshmanan et al., 2011). When teachers can participate in group collaboration and peer-to-peer reflection, student achievement increases (Rigelman & Ruben, 2012). Without group support, teachers often model the practices they experienced while in school which involved teaching in isolation with little collaboration or mentorship (Darling-Hammond, 2010; Rigelman & Ruben, 2012). Since PLCs are defined by DuFour et al. (2016) as collaborative teams of teachers who assume collective responsibility for the learning within a domain (science) and/or level (secondary), PLCs build an environment that is conducive to continuous improvement (Stoll et al., 2006), fostering teachers' professional development to enhance student learning (Lomos et al., 2011). Research by Voelkel and Chrispeels (2017) suggests that these effects are strengthened when PLCs are supported by the district, PLCs may also provide a way to support district reform efforts by delivering and reinforcing DLPD and promoting collaboration (DuFour et al., 2008) and reflection (Sæbø & Midtsundstad, 2022) among currently collaborating teachers. Therefore, providing teachers with DLPD, embedded within PLCs, may provide unique opportunities for science teachers to take generalized knowledge of 21st century skills from the DLPD and contextualize that information within and to their content (biology) curriculum and instructional practices.

## Research Purpose

This exploratory case study sought to understand teachers' perceptions of the effectiveness of DLPD on 21st century learning, disseminated and reinforced through three biology PLCs at three main high schools within a single school district. Using Desimone and Pak's (2017) conceptual framework of effective PD, data was collected and analyzed at three PLC sites to model how teachers perceived the effectiveness of the DLPD and to examine to what extent that 21st century learning was occurring within the participating teachers' biology classrooms Therefore, the research question guiding this study was, what were teachers' perceptions of effectiveness of DLPD on 21st century learning in PLCs and how did their experiences manifest as changes to practice in 21st century learning in the classroom?

## Methods

This exploratory multiple case study aimed to examine how teachers perceived the effectiveness of DLPD on 21st-century skills embedded within PLCs and how teachers translated that PD into changes in their C&I practices in their biology classes for 21st-century learning in the 4Cs. The use of a case study design allowed the researcher to purposefully select cases for replication (Yin, 2018) to determine similarities and/or differences (patterns) in biology teachers' perceptions of effective PD. The multiple cases reflect the naturalistic variety of PLCs that exist among schools, even within the same school district. However, the case is bound by the high school teachers who participate in one of the three biology PLCs in a single school district who received DLPD in 21st-century skills. This boundary is important to not only have replicable forms of the DLPD delivered to each group focusing on one salient science content area (biology), but also to not introduce threats to validity as 21st-century learning may be defined differently between school districts. Notably, this study is part of a dissertation study on the influence of PLCs on district PD (James, 2019).

### Case Limitations and Delimitations

Limitations of this study relate to the compulsory nature of teachers' PLC participation. Because PLCs are a district initiative, many of the expectations and norms typically created through the processes of PLCs (timing and regularity of meetings) were pre-defined by the district and campus administration. However, the week-to-week operation of sampled PLCs had previous to and during the research study been driven by teachers (rather than by administrators and/or researchers), which mitigates this limitation. Creswell (2013) describes a limitation of the case approach study is that it is based on cases within a bounded system and "what he means by

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bounded is that the researcher makes very clear statements in the research objectives about the focus and the extent of the research" (Farquhar, 2012, p. 7). Thus, case studies can be difficult to replicate (Simon & Goes, 2013) and challenging to draw generalizations from their findings (Yin, 2013). However, the applicability of this case to other contexts is strong as most U.S. schools employ a PLC or PLC-like model as a means for teacher learning and improving teachers' practices (Basileo, 2016) and the use of extant theory strengthens findings and contributions of this case to the field (Tsang, 2014). The study is delimited to one content area (biology) PLC team from each of the three traditional high school campuses in a single school district. The PLC process for other content areas (outside of science) was not taken into consideration for this study.

**Context of the District**

The district in this study is a suburban district in the southwestern United States. The district serves approximately 24,000 K-12 students and employs 3,000 faculty and staff. Student demographics for the district are 61% Hispanic, 19.7% Caucasian (non-Hispanic white), 15.5% African American, 1.7 % Asian, and less than one percent Native American. Approximately 64.4% of students are federally recognized as economically disadvantaged, 15.2% are designated as English language learners, and 9.9% qualify for special education services. In the district, there are sixteen elementary campuses, five junior school campuses, two early college high schools, two alternative campuses, and three traditional high schools. The three traditional high schools (referred to herein as School A, B, and C, respectively as pseudonyms) are the sites for the study.

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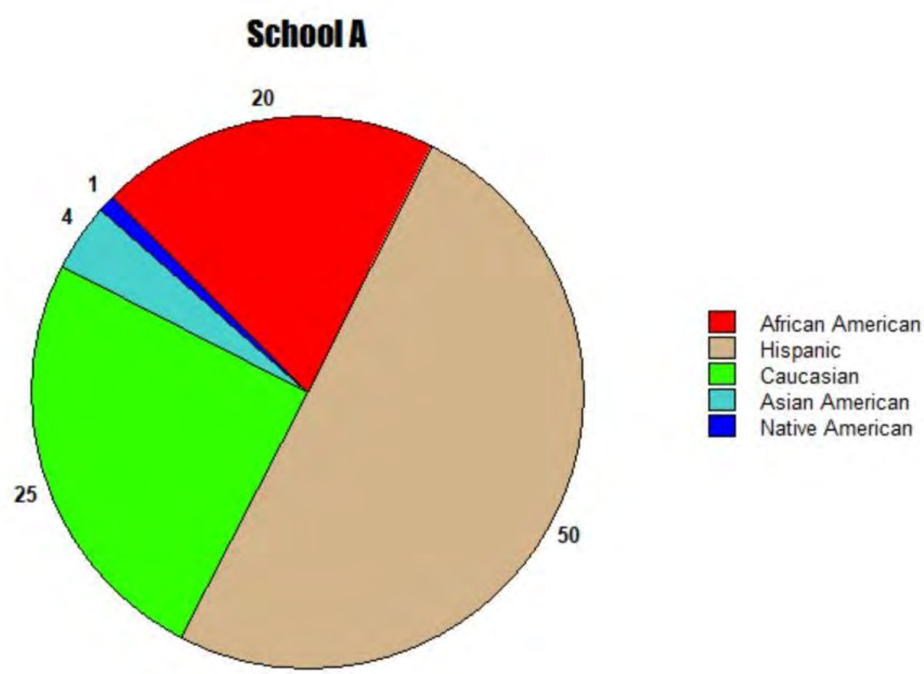
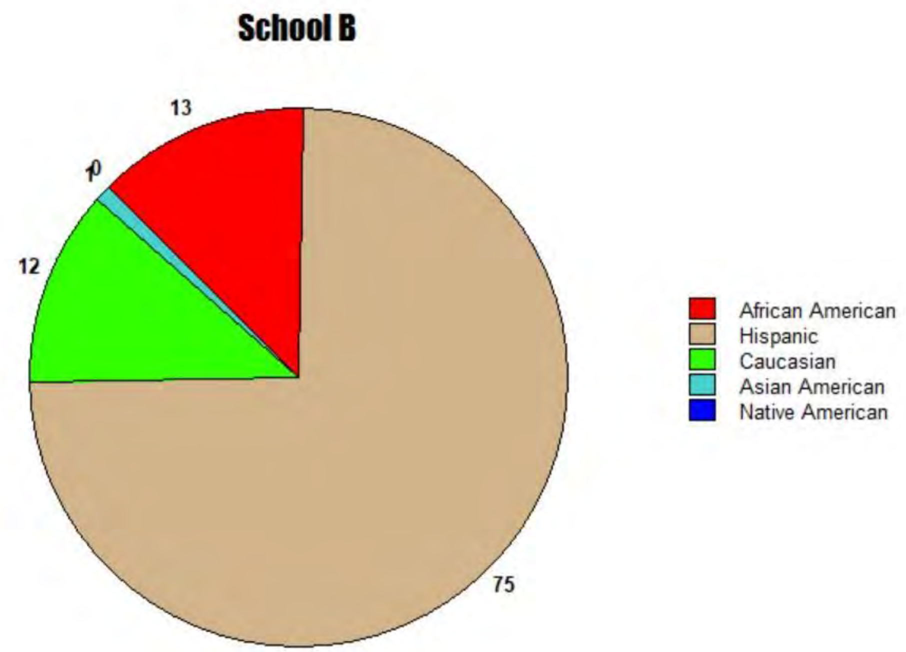
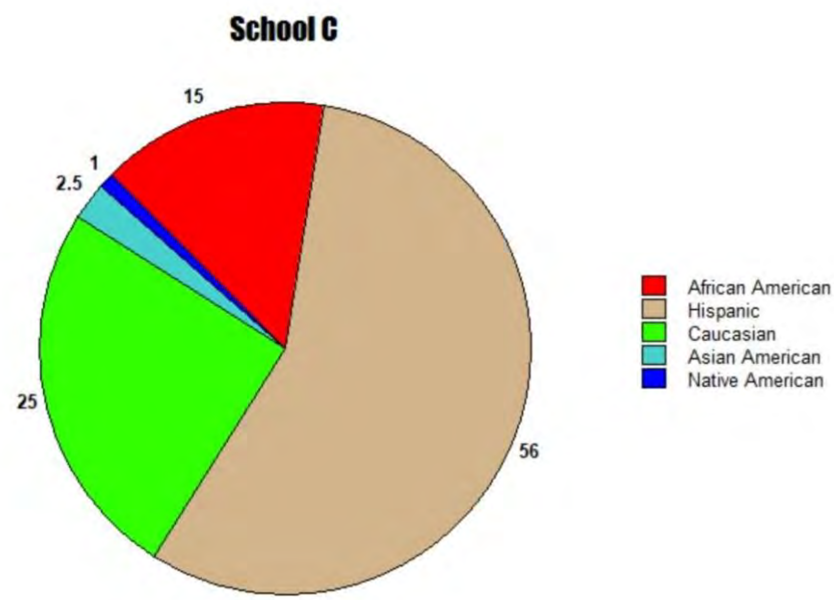
Figure 1 displays the student demographics of the schools during the 2017-2018 school year in which the study was conducted, School A had 2,159 students enrolled, 47.8% of which were categorized as economically disadvantaged, 4% as English language learners, and 9% as receiving special education services. In school B, 75% of the student population was categorized as economically disadvantaged. In school C, 58% of the students were categorized as economically disadvantaged, 8.1% were English Language Learners, and 10.7% were receiving special education services.

**Figure 1.**

*Demographic Percentages of Students by Schools A, B, and C*






**Context of the Schools (Cases) and District: DLPD for 21st Century Learning**

At the beginning of the school year in August of 2018, participating teachers were required to attend a three-day *science PD academy* provided by the district C&I department. The science PD academy for the 2018-2019 school year focused on 21st century learning for science teachers; a decision made to address a critical component of the district's mission and vision for all high school learners to garner 21st century skills. The specific 21st-century skills were defined as the 4C's of communication, collaboration, critical thinking, and creativity (NEA, 2012; P21, 2015). Each day of the DLPD was designed such that teachers received information and research-based strategies for promoting students' critical thinking, problem-solving, collaboration, and creativity. For day one, teachers were provided with ways to motivate deeper, more meaningful thinking that leads to enduring learning through the lens of 21st century skills and learning. To challenge and engage students in deeper and more meaningful thinking processes, teachers envisioned activities that were less teacher-centered and placed more emphasis on using phenomena to spur curiosity and questions. For day two, DLPD focused on the alignment of instruction by 'unpacking' the state standards and identifying key content vocabulary to support effective communication in the classroom using interactive word walls. For day three, teachers self-assessed their teaching practices and experience strategies in the areas of oral and written communication, collaboration across networks, critical thinking and problem-solving to their own content area and level. Upon completion of the three-day science PD academy, participants received additional PD on 21st century skills in the school level Biology PLCs. During the PLC time during the semester, biology teachers in each team discussed 21st century teaching and learning by adapting lesson plans to include 4C elements, created common assessments to measure 4C growth, and discussed strategies and activities for upcoming life science content to better include 21st century skills. Further, PLCs reviewed data from biology benchmark examinations (common assessments) measuring mastery from across the district's high schools.

## Context of the Study

The present study took place during the fall semester of 2019 (August to December) after a three-day district PD at the beginning of the school fall semester and concluding at the December holiday. Data was collected from 14 biology teachers who participated in biology PLCs at three separate high schools within a single school district. Case data was sourced from PLC and classroom observations, PLC agendas, lesson plans, and teacher interviews from each school site. The following sections describe the participants and data collection process.

### *Context of the Participants*

Biology was the only common science course that all students must take during their 9th-grade year to graduate from high school. Further, biology PLCs were an ideal site for study because, in this district, they were required to regularly meet and could fully participate in the DLPD through the fall semester. Table 1 shows the Biology PLC meeting schedule and participating biology teachers (with pseudonyms). Notably, School A, B, and C do not meet as a PLC on the same days or for the same amount of time, (270, 235, and 140 minutes total respectively). Each PLC membership is approximately 4 to 5 biology teachers, with varying amounts of time participating in the PLC (1-3 years) and years of teaching experience in the district (1-13 years).

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Table 1.
*Background Information on PLCs and Participating Teachers*

| School Location<br>Biology Teachers | Biology PLC Meeting | | Participating High School | | | | |
|---|---|---|---|---|---|---|---|
| | *Time (minutes)* | *Dates (per week)* | *Assigned Pseudonym* | *Demographic Information** | *Life Science Certification* | *Years of Teaching Experience in District* | *Years in PLC* |
| School A | 90 | 3 times | Carla | NW, F | K-12, ESL | 3 | 3 |
| | | | Terrie | W, F | 8-12 | 5 | 3 |
| | | | Taylor | W, F | 8-12 | 6 | 3 |
| | | | Bethany | NW, F | 8-12 | 10 | 3 |
| School B | 47 | 5 times | Allison | W, F | 8-12, ESL | 3 | 3 |
| | | | Haley | W, F | 8-12 | 8 | 3 |
| | | | Autumn | W, F | 7-12 | 3 | 3 |
| | | | Raymond | W, M | 6-12 | 3 | 3 |
| | | | Briana | W, F | 7-12 | 1 | 1 |
| School C | 35 | 4 times | Martin | NW, M | 7-12, ESL | 3 | 3 |
| | | | Summer | W, F | 7-12 | 11 | 3 |
| | | | Misty | W, F | 7-12 | 1 | 1 |
| | | | Claire | NW, F | 7-12 | 1 | 1 |
| | | | Stacie | W, F | 6-12 | 13 | 3 |

*NW stands for "Non-white", W for "White", F for "Female" and M for "Male"

**PLC Context.** The district had implemented PLCs four years prior to the time of the study. Representatives from each campus and their administrators attended a PLC conference provided by Solutions Tree™. Each summer, additional campus representatives attend the PLC conference and bring what they learned back to their campuses. The conference used *Learn by Doing* by DuFour et al. (2016) to guide the process. Regarding structure, the biology PLC at School A met every other day (block period) during the school day for 90 minutes. Each member had a period dedicated for their PLC work and a separate *conference* period (i.e., an individual planning period). At school B, the biology PLC met daily during the school day for 47 minutes.

Like School A, each member of the biology team had a period for their PLC time and a separate conference period. At School C, their biology PLC met Mondays, Tuesdays, Thursdays, and Fridays before school for 35 minutes. Wednesday was reserved for each member to have tutorials for their students. Each member of the biology team also has a conference period each day.

**Data Collection**

For the case study, several data sources were employed to capture perceptions of the PLC and the manifestation of the PD knowledge to practice in the classroom. First, observations of the PLC meetings with the biology team were conducted to determine which teaching strategies were implemented in the classroom. The protocol was entirely open-ended, recording all interactions among members. Approximately nine observations were made, per school, during the semester. The observations took place in their natural setting and were observed first-hand by the researcher. Second, teachers' biology lesson plans, PLC agendas and meeting minutes were collected from each of the schools for data analysis.

Third, upon completion of PLC and classroom observations, a series of interviews were conducted with biology teachers and the PLC leader. Interview questions were piloted during the Spring 2017 semester with one campus PLC which refined the questions to better capture teachers' perceptions of effective science PD. Further, two science education researchers reviewed the questions for alignment to the Desimone and Pak (2017) framework. Interviews were thirty minutes and audio-recorded for transcription. The interviews conducted were one-on-one and semi-structured based on an interview protocol (Appendix A) supported by field notes taken by the researcher. After transcripts were developed, participants had the opportunity to review the transcripts (member-checking) to make any needed changes. No participants made any change to the transcript at that time.

**Analysis**

Data was transcribed, loaded into *Dedoose* version 8.3.17 software (2019), and were coded *a priori* based on the constructs of effective PD (content-focused, active learning, collective participating, duration, and coherence) per Desimone and Pak (2017) and the framework's supporting literature (Darling-Hammond et al., 2016; Desimone, 2009). Codes for 21st-century skills were developed *a priori* using the 4Cs of collaboration, communication, critical thinking, and creativity, sourced from the literature (NEA 2012; P21, 2009) for interview, document, and observation data. The codebooks for evidence of effective PD and 21st-century learning are found in Appendices B and C, respectively. Gradation in levels of implementation (i.e., from emergent, developing, proficient, accomplished, and distinguished) helps to visualize and qualify the perceptions reported and observations made from teacher data. Salience was determined through frequency counts by case (Schools) and then compared with each case to visualize similarities and differences in perceptions of effectiveness and the manifestation of 21st-century learning by participating biology teachers in their classrooms.

This study used a pattern-based cross-case analysis, given there is more than one case, to maintain the integrity of the individual cases while looking for similarities and differences (Yin, 2018). Upon analysis of each individual case, data from each case were used to determine similarities and differences (via pattern analysis) among frequencies counts of data by constructs of the framework. Chi-square was employed to determine significant differences between categories and ascertain if there were outliers that may unduly influence case analyses and

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pattern-based comparisons.

To ensure the trustworthiness of the study's findings, the research design followed an inductive approach by gathering data, looking for patterns that emerge from the data, and using theory to match said patterns (Hesse-Biber, 2017; Yin, 2018). Credibility was established by employing different types of data collection (Shenton, 2004) through interviews, observations, and documents and transferability was met by following an established case protocol and analysis (Yin, 2018). Member checking was performed after interviews were transcribed in which the interviewees were able to review the transcripts for accuracy (Hesse-Biber, 2017) and interrater reliability was conducted at the start of data analysis. Using a small (10%) sampling of all data, two coders yielded an initial percent agreement of 75%. The two coders debriefed and discussed their rationale for coding, which refined the codebook. Both coders coded the entire data set, yielding a percent agreement of 90%. To best report findings in a transparent way, an audit trail was created and presented chronologically by numbers in superscript throughout the results section and summarized by data type, data source, and data collected in Appendix D.

## Results

The summary of data from teachers at each of the three PLCs on their perceptions of the effectiveness of the 21$^{st}$ century learning DLPD in PLCs, at various levels of implementation, is shown in Table 2. A chi-square test of independence examined the relationship between school locations and observations, and yielded a non-statistically significant result**,** $X^2$ (X, $N$ = 225) = 14.82, $p$ >.05. A pattern analysis narrative follows that describes similarities and differences in teachers' perceptions of the DLPD in PLCs on 21$^{st}$ century skills.

Table 2.
*Cross Case Analysis of Frequencies of Constructs of Effective PD in Observation data (including document analysis, classroom observations and PLC observations) from Case A, B, and C Teachers*

| Constructs of Effective PD (N = 225) | Cross Case Analysis | | | | |
|---|---|---|---|---|---|
| | Emergent (*n* = 25) | Developing (*n* = 38) | Proficient (*n* = 85) | Accomplished (*n* = 56) | Distinguished (*n* = 21) |
| **Content Focused** (*n* = 58, 26%) | 2 (3%) | 7 (12%) | 29 (50%) | 15 (26%) | 5 (9%) |
| **Collective Participation** (*n* = 54, 24%) | 8 (15%) | 12 (28%) | 15 (28%) | 13 (24%) | 6 (11%) |
| **Coherence** (*n* = 53, 54%) | 7 (13%) | 8 (53%) | 19 (36%) | 14 (26%) | 5 (9%) |
| **Active Learning** (*n* = 51, 23%) | 8 (16%) | 9 (18%) | 20 (39%) | 9 (18%) | 5 (9%) |
| **Duration** (*n* = 7, 3%) | 0 (0%) | 2 (29%) | 2 (29%) | 5 (71%) | 0 (0%) |

**Similarities**

Similarities between cases were identified for the constructs of effective PD. One similarity between cases was how they defined PD. Each of the participants interviewed defined PD as a way to increase their content and pedagogical knowledge.[1-5] When asked to explain the purpose of PD, the teachers for all cases said the primary purpose was to help make them better teachers.[6-13] Terrie from School A elaborated by adding that it also helped to increase student achievement.[14]

In each of the cases, the content-focused construct was observed at the highest frequency. The teachers each shared several examples of how they felt the PD was more meaningful when it could be taken directly back to their classrooms to use with the students. For each of the three cases, collective participation and active learning were observed equally. Each of the nine teachers interviewed shared how the group dynamic and team learning was important for their

PD opportunities in the PLC. The teachers recognized the importance of working together as a team and were able to build upon the input of each group member to create meaningful experiences for both the teachers and their students.[15]

When asked about their knowledge of 21st century skills, several interview participants across the cases mentioned the use of technology in the educational setting.[16-18] Each case related 21st century skills to critical thinking or problem solving for their students.[19-27] Tracie specifically mentioned in her interview that she felt that many of the teachers lacked true understanding of 21st century skills and lacked the PD needed to properly transfer the skills in their classrooms, [28] suggesting that garnering an awareness of 21$^{st}$ century skills was the primary activity among teachers in the PLC rather than knowledge acquisition and application to practice.

**Differences**

Each of the three schools had a different construct with the most observations. At School A, collective participation (*n* = 21, 23%) was most observed[29-32], whereas School B had content focus (*n* = 23, 16%) as most observed[33,34], and coherence (*n* = 17, 14%) was the most frequently observed at School C.[35-37] Both School A and B requested additional training during their PLC on the implementation of supplemental aids. Supplemental aids are paper-based designated supports allowed by the TEA (2019) for the recall of information during state assessments. In order for a student to use the supplemental aid during state testing, there has to be evidence of the student using the aid with success in the classroom. School A was the only biology team to implement supplemental aids with their students.[39] Additionally, School A teachers conducted observations of each other's classrooms, focused on certain activities based on discussions during their PLCs.[40] The goal of the meetings was to see how the lessons they planned as a group were implemented in the classroom. The teachers would come back together in the PLC to share what they observed in the classroom. One example at the accomplished (*n*=3, 15%) level for School B was when Autumn attended the district PLC for biology teachers and brought back resources for the team.[41] She presented the lesson over the cell cycle and had the team participate in the lesson and then discuss how to implement it in their classes.

The data from the interviews and PLC observations of the biology teachers from Schools A, B, and C, illuminated how 21st century learning manifested in participating teacher's practices at various levels of implementation as shown in Table 3. A chi-square test of independence was performed to examine the relationship between schools and construct frequencies of observed 21st century learning. The result was not significant, $X^2$ (X, $N$ = 131) = 4.07, $p$ >.05. A narrative pattern analysis follows that describes how similarities and differences in teachers' implementation were observed and interpreted.

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Table 3.
*Cross Case Analysis of Observation Frequencies of Constructs of 21st Century Skills in Observation data (document analysis, classroom observations, and PLC observations) from School A, B, and C Teachers*

| **Sub-Constructs of 21$^{st}$ Century Skills ($N$ = 131)** | **Cross Case Analysis** | | | |
|---|---|---|---|---|
| | **Emergent** ($n$ = 38) | **Developing** ($n$ = 52) | **Approaching** ($n$ = 35) | **Proficient** ($n$ = 6) |
| **Communication** ($n$ = 43; 33% of construct) | 10 (23%) | 18 (42%) | 13 (31%) | 2 (5%) |
| **Critical Thinking** ($n$ = 36; 27% of construct) | 12 (33%) | 12 (33%) | 11 (31%) | 1 (3%) |
| **Collaboration** ($n$ = 35; 27% of construct) | 9 (26%) | 16 (46%) | 8 (23%) | 2 (6%) |
| **Creativity** ($n$ = 17; 13% of construct) | 7 (41%) | 6 (35%) | 3 (18%) | 1 (6%) |

### Similarities

For each case, communication (*n*=43, 33%) was the most observed construct and was assessed at the developing (*n*=52, 38%) level. Notably, the majority of classroom applications of all four 21st-century skills observed were assessed at the developing level. That is, teachers in each of the cases had provided opportunities for their students to engage in instruction that promoted critical thinking through higher order thinking questions and to communicate in multiple ways. However, more advanced techniques in 21st-century teaching, like making global connections or relationships to real-world concepts, were fewer.

Another similarity between cases was observed during the PLCs; each of the schools created an intervention plan based on their students' data. School A created an intervention plan based on common assessment data and created classroom activities that promoted student

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mastery of the content or provided enrichment for students who mastered the content. Each of the teachers worked together to create activities that incorporated the constructs of 21st-century skills. School B created its intervention plan based on data to better prepare the students for their fall final exam. Together, the team created a three-day station rotation that allowed the students to participate in board games created not only to increase their content knowledge but also to engage the students in 21st-century skill development. School C used the data to create weekly *WIN* (what I need) time activities that focused on standards in which students did not meet mastery. Lastly, each of the schools implemented interactive word walls in their classrooms to promote using academic vocabulary. Each teacher within the schools had their own take on the word walls (e.g., on the content of study, concepts mastered, integrating concepts from previous units), but each classroom that was visited had the word walls posted for previous units that had incorporated student work.[42-44]

**Differences**

Observations support that teachers' participation in their PLC allowed them to reflect upon how they felt during the activity and then share with the team providing examples of ideal communication and collaboration activities.[45] For example, during one PLC, School A teachers discussed the essential question or higher order thinking question they were going to use to guide their instruction over photosynthesis and cellular respiration. Each teacher would base their lesson around the question "Would it be advantageous if we as people could do photosynthesis? Why or why not?"[46] Terrie (School A) had her students participate in a class debate and the students had to take a side and argue their point of view.[47] During a classroom observation, Allison (School B) used a strategy from the back-to-school academy that promotes collaboration

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(at the approaching level, *n*=3, 18%), communication (at the approaching level, *n*=1, 5%), and reading. Each of the students worked in pairs or groups of three to correctly sequence a set of cards based on the steps of photosynthesis.[48] During a PLC observation in School C, the ESL specialist and science specialist presented strategies the teachers could use with the interactive word walls that they and learned about in the back-to-school academy training.[49] The team applied the interactive word wall strategies and sentence stems to promote critical thinking (at the approaching level, *n*=3, 25%) during the lesson on biomolecules.[50] However, School C had very little evidence of emergent level implementation (*n*=4; 3%) for any sub-construct. Notably, School B provided their students with multiple opportunities to utilize their iPads/technology as a tool for communication.[51-55]

## Discussion

The purpose of this multiple case study was to explore biology teachers' perceptions of DLPD within PLCs as an effective way to develop their knowledge of 21st-century skills and implement pedagogies to develop students' 21st-century skills in their science classrooms. Using the constructs of 21st-century learning (P21, 2015) and constructs of effective PD by Desimone and Pak (2017) and Desimone (2009) within the context of the PLC model (DuFour et al., 2016) with five levels of implementation (emergent to distinguished) on a rubric scale, this study modeled how PLCs were effective vehicles for DLPD in 21st-century skills for sampled biology teachers and how 21st-century learning from effective PD manifested into classroom practices. Regarding to what extent, if any, participating teachers perceived the 21st-century focused DLPD embedded within the biology PLCs to be effective, this study found that coherence was greatest (54%), followed by content focus (26%), collective participation (24%), active learning

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(23%), and last, duration (3%). Each construct of effective PD is discussed followed by observations of 21$^{st}$ century learning in the classroom to infer to what extent the findings affirm, refute, and extend the current literature base on DLPD in PLCs.

Coherence ensures that C&I materials are aligned with policies (Stosich et al., 2018), which drives most of American K-12 education (Lindvall & Ryve, 2019). Coherence is important to teachers of science in PD in PLCs by providing "ongoing contact with a community of like-minded educators for collaboration and recognition" (Kohnen & Whitacre, 2017, p. 414). Participants also take part in decision-making through collaborative activities that allow for joint responsibility (Harris & Jones, 2010). Reflective dialogue among teachers in PLCs has been identified as a salient factor toward changes in teachers' practices (see Vanblaer & Devos, 2016). Given this was a main thrust of the biology PLC (and year-end accountability in state testing), coherence played a large role in binding the groups and trusting each other in their activities (Melville & Wallace, 2007). Since all biology teachers in the school district were given the common charge of integrating 21st-century learning into their classrooms, this common purpose likely contributed to sampled teachers' perceptions and observations of collective participation for a common goal (Desimone & Pak, 2017; Stoll et al., 2006). Further, findings suggest that the PLC allowed teachers to problem-solve lesson planning, through collaborative inquiry, to collectively devise means to foster 21st-century learning experiences (DuFour et al., 2016). The level of active learning observed in the present study allowed the teachers to use the PLC as a place to reflect upon their practices and provide both internal and external accountability (Ingvarson et al., 2005).

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Duration, or the amount of time spent on the PD activity (Desimone & Pak, 2017; Desimone, 2009), was the least observed in the present study. This finding may suggest that PLCs are not an ideal environment for PD due to a lack of time. Fidelity of implementation improves when PD is provided over an extended period with coaching and mentoring throughout the semester (Desimone, 2009). Research suggests that collaborative activities that focus on student learning over a long period are more effective forms of teacher PD compared to PD that does not have these elements (Darling-Hammond, et al., 2009; Ingvarson et al., 2005; Prenger et al., 2017). Notably, all teachers were new to the 21st-century learning PD, so there were no embedded coaches and mentors to serve as more capable peers in the PD processes per the fidelity of implementation requirements. Had the teachers been at different points in their awareness, knowledge, and implementation of 21st-century skills, we may have seen a more robust outcome in this area.

Among the four 21st-century skills of interest in this study, communication and collaboration were the most frequently observed constructs among teacher discussions for all three cases, further illuminating the need for teachers to integrate critical thinking and creativity skills into instruction (Astuti et al., 2019) and the efficacy of the PLC to provide a space to foster creation and sharing of ideas (Huffman & Jacobson, 2003). Observations support the notion that there were few opportunities for students to be creative or be involved in high-level critical thinking activities.[58-62] For example, each teacher used essential questions or higher-order thinking questions to drive the lesson but rarely allowed the students to engage in lessons based on inquiry or problem/project-based learning.[63-67] During interviews, teachers mentioned problem-solving skills when asked about 21$^{st}$-century skills, yet only one teacher, Terrie, used

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phenomena (as a problem-solving skill) to drive her lesson.[68] Teachers need to reflect upon the activities they provide to students to determine if they allow the students to develop critical thinking and problem-solving skills; per Stewart, "when teachers take the time to investigate the work students are doing, they can then develop professional learning projects around targeted improvements in lessons and assessment" (2014, p. 28). This finding is important as research by Gunawardena and Wilson (2021) suggests that teachers perceive aspects like critical thinking as 'a product' instead of a process, which augments how they teach critical thinking. The authors suggest that "teachers can overcome this dilemma by developing a culture of thinking in the classroom by overtly scaffolding students' development of CT, thus making the process much more visible for students" (p. 1). Some of this reflective preparation was conveyed during PLC time; PLC observations provided evidence that the teachers 1) valued the time to collaborate during their PLCs, 2) used PLC time to communicate effective strategies for their students, 3) identified areas of need, and 4) co-constructed their content knowledge and teaching biology concepts with 4C integration.

Regarding the implementation of the DLPD in biology classrooms, we found that communication (33%), critical thinking (27%), collaboration (27%), and creativity (13%) were discussed and observed as evidence of 21st-century learning. Notably in each of the cases (Schools A, B, and C), collaboration was observed in the classroom at the developing level. According to DuFour et al. (2016), "the purpose of collaboration—to help more students achieve at higher levels—can only be accomplished if the professionals engaged in collaboration are focused on the right work" (p. 59), which warrants a *high functioning* PLC typified by collective efficacy (Voelkel & Chrispeels, 2017). Yet, Jones et al. (2013) found in their work on the group

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dynamics of science PLCs that collaboration varied greatly, and "a significant concern was the impact of problematic interpersonal relationships and communication styles on the group functioning" (p. 1756). Therefore, care should be taken to ensure PLCs are centered around the four questions that drive PLC work (DuFour et al., 2016) and shared norms of collaboration and communication. To assist in this process, PLC agenda and planning documents can be restructured to serve as a scaffold and driving force of the process (DuFour, 2004; DuFour et al., 2016). For example, only School A teachers learned in their PLC useful biology-focused sentences from the ESL specialist. We believe that the sharing of best practices in collaboration can help to reduce the variance of experiences in DLPD among PLCs across schools within the district.

Moreover, each case had evidence to support critical thinking and creativity, even though classroom implementation of these skills in curriculum and instruction were at the lower levels and least observed, respectively. A study of pre-service chemistry teachers by Shidiq and Yamtinah (2019) found that participants had a good understanding of creativity from PD but had a lack of experience in translating that knowledge into practice. Similarly, sampled in-service teachers may have also experienced challenges in integrating creativity into their biology lessons, and why creativity was poorly observed in the present study. Regardless, this finding suggests that PD opportunities should better incorporate strategies for introducing critical thinking and creative curriculum and instruction for students. One aspect that was notably lacking in the biology PLCs' processes was in identifying the essential standards (DuFour et al., 2016) for critical thinking and creativity; both identification and clarification are vital components of PLCs to readdress specific learning targets (Moss & Brookhart, 2012). We suggest a scaffolding of 4C integration, beginning with communication and collaboration skills and transitioning into problem-solving and creativity, to allow teachers to generate an awareness of these skills, garner greater knowledge of the skills, and layer those skills into their biology curriculum and instruction.

## Conclusion

As PD opportunities become more elusive to teachers and PLCs are established as a standard for working groups of teachers related to professional learning and practice, it is important to study how teachers perceive the effectiveness of PD in these unique spaces and to support 21st-century teaching and learning in the sciences. This study suggests that PLCs are an effective means to embed DLPD by bringing coherence to district-led initiatives and a stronger content focus by allowing teachers to work collaboratively within a common content area. In terms of how sampled teachers translated the PD into practice from the DLPD in biology PLCs on 21st-century learning, teachers excelled in the areas of growing their awareness of communication and collaboration, but not in providing curricular and instructional means to grow critical thinking skills and enacting creative opportunities for their science learners. This study extends the current PLC literature by describing how teachers' perceptions of effective PD, coupled with observations and document analyses, manifested into implementation within different schools in the same district. Specifically, this study shows when the focus of DLPD is to implement strategies for a specific task (i.e., the 4Cs), teachers spent PLC time becoming aware of the PD concepts and implemented those strategies at nascent levels. As they began to 'try-out' these strategies in the classroom, they shared their experiences and felt supported by their respective PLCs, which was evidenced in their reflective discussions.

One promising contribution of this study is *how* to leverage PLCs for collaborative PD with district support. In one semester, PLC members transitioned from lesson planning (instruction) to requesting additional training during their PLCs to focus on application and assessment systems, which have shown to increase teacher knowledge building (Popp & Goldman, 2016). Future research and practitioner reforms should examine how best to pivot PLCs from passive conversations to active collaborations in improving C&I to enhance 21$^{st}$ century learning in the sciences.

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# Appendix A

## Interview Protocol

1. How would you define a PLC? What do you think is its purpose?
2. Describe PLCs, in general (for example, PLCs on your campus).
3. Describe your PLC. What are typical experiences in the PLC? (What do you "normally" do in your PLC during PLC time?)
4. In what ways do you feel that (your) participation in the Biology PLCs has benefitted (you or your teachers) in your/their classroom practices:
5. Content Knowledge?
6. Pedagogical Knowledge?
7. 21st Century skills and practices?
8. Other? (Probe for any additional benefit like efficacy or STEM career awareness)
9. In what ways do you feel that (your) participation in the Biology PLCs has NOT benefited (you or your teachers) in your/their classroom practices:
10. If so, in what way?
11. How could the PLC be restructured to better serve you or your teachers? (Probe for not just the PLC but also structural issues like time, collaboration, etc.)
12. Anything else you want to share about PLCs?
13. District Led PD
14. How would you define a PD? What is its purpose?
15. Describe PD, in general, on your campus.
16. Describe the PD you received in your PLC. What were the "typical" PD activities participants (you or your teachers) engaged in during the Biology PLC?
17. In what ways do you feel that (your) participation in the PD provided during the Biology PLCs has benefitted (you or your teachers) in your/their classroom practices:
18. Content Knowledge?
19. Pedagogical Knowledge?
20. 21st Century skills and practices?
21. Other? (Probe for any additional benefit like efficacy or STEM career awareness)
22. In what ways do you feel that (your) participation in the Biology PLCs has NOT benefited (you or your teachers) in your/their classroom practices:
23. If so, in what way?
24. How could the PLC be restructured to better serve you or your teachers?
25. (Probe for not just the PLC but also structural issues like time, collaboration, etc.)
26. What are your thoughts on embedding (any) PD with PLCs?
27. What are your thoughts on embedding this (e.g. district-led, focused) PD with your PLC?
28. What type of other PD do you think may be beneficial (to you or your teachers) embedded into this PLCs or other content/grade-level/etc. PLCs?
29. Anything else you want to share about District Led PD in PLCs?

## Appendix B

## Codebook for Effective PD

| | **teacher centered** | Evidence of Demonstration of Skill for Effective PD (0 for not shown) | | | **student centered** |
|---|---|---|---|---|---|
| Constructs | emergent (1) | developing (2) | proficient (3) | accomplished (4) | distinguished (5) |
| | | | | | |
| | Few goals aligned to state content standards. | Most goals aligned to state content standards | All goals aligned to state content standards. | All measurable goals aligned to state content standards | All rigorous and measurable goals aligned to state content standards |
| coherence (co) Defined as: ensures that there is a consistency within the school, district, and state reform policies to align | Few activities, materials and assessments that are sequenced | Most activities, materials and assessments that are sequenced | All activities, materials and assessments that: - are sequenced -are relevant to students - provide appropriate time for lesson and lesson closure - fit into the broader unit and course objectives - are appropriate for diverse learners | All activities, materials and assessments that: - are sequenced -are relevant to students - provide appropriate time for lesson and lesson closure - fit into the broader unit and course objectives - are appropriate for diverse learners | All activities, materials and assessments that: - are logically sequenced - are relevant to students' prior understanding and real-world applications - integrate and reinforce concepts from other disciplines - provide appropriate time for student work, student reflection, lesson and lesson closure - deepen understanding of broader unit and course objectives - are vertically aligned to state standards - are appropriate for diverse learners |
| | | | | | |
| collective participation (cp) Defined as: groups of individuals coming together with a common goal or purpose | Directs lessons with little opportunity for dialogue, clarification or elaboration | Leads lessons with some opportunity for dialogue, clarification or elaboration. | Establishes classroom practices that provide opportunities for most students to communicate effectively with the teacher and their peers | Establishes classroom practices that encourage all students to communicate effectively, including the use of visual tools and technology, with the | Establishes classroom practices that encourage all students to communicate safely and effectively using a variety of tools and methods with the teacher and their peers. |

| | | | | | |
|---|---|---|---|---|---|
| | | | | teacher and their peers | |
| | Rarely asks questions, or asks questions that do not amplify discussion or align to the objective of the lesson. | Asks remember and understand level questions that focus on the objective of the lesson but do little to amplify discussion. | Asks remember, understand and apply level questions that focus on the objective of the lesson and provoke discussion | Asks questions at the creative, evaluative and/or analysis levels that focus on the objective of the lesson and provoke thought and discussion. | Asks questions at the creative, evaluative and/or analysis levels that require a deeper learning and broader understanding of the objective of the lesson. |
| | | | | | |
| content focused (cf) Defined as: demonstrating to the participating teacher the link between their content and the skills they are learning in order to make improvement | Conveys inaccurate content knowledge that leads to student confusion. | Conveys accurate content knowledge | Conveys accurate content knowledge in multiple contexts. | Conveys a depth of content knowledge that allows for differentiated explanations | Displays extensive content knowledge of all the subjects she or he teaches and closely related subjects. |
| | Rarely integrates learning objectives with other disciplines | Sometimes integrates learning objectives with other disciplines. | Integrates learning objectives with other disciplines. | Integrates learning objectives with other disciplines and real-world experiences | Integrates learning objectives with other disciplines, content areas and real-world experience. |
| | | | | | |
| active learning (al) Defined as: characterized by methods other than listening to lectures, | Establishes a learning environment where few students are engaged in the curriculum. | Establishes a learning environment where most students are engaged in the curriculum. | Engages all students in relevant, meaningful learning. | Engages all students with relevant, meaningful learning, sometimes adjusting lessons based | Consistently engages all students with relevant, meaningful learning based on their interests and abilities to create a positive rapport amongst students. |

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| | | | | | |
|---|---|---|---|---|---|
| active learning can take a number of forms, including observing expert teachers or being observed, followed by interactive feedback and discussion | | | | on student interests and abilities. | |
| | Students are disrespectful to each other and to the teacher. | Students are sometimes disrespectful to each other. | Students work respectfully individually and in groups. | Students collaborate positively with each other and the teacher. | Students collaborate positively and encourage each other's efforts and achievements. |
| | Rarely provides opportunities for students to take initiative for their own learning. | Sometimes provides opportunities for students to take initiative for their own learning. | Provides students opportunities to take initiative for their own learning. | Establishes systems where students take initiative for their own learning and self-monitor. | Systematically enables students to set goals for themselves and monitor their progress over time. |
| | | | | | |
| duration (du) <u>Defined as</u>: the amount of time, including both span of time over which the activity is spread, and the number of hours spent in the activity in order to bring about teacher change | Engages in few professional development activities, professional learning communities or committees to improve professional practice | Engages in most scheduled activities, professional learning communities, committee, grade- or subject-level team meetings as directed. | Collaboratively practices in all scheduled professional development activities, campus professional learning communities, grade- or subject-level team membership, committee membership or other opportunities. | Fosters faculty knowledge and skills in support of the school improvement plan through professional learning communities, grade- or subject level team leadership, committee membership or other opportunities beyond the campus. | Develops and fulfills the school and district improvement plans through professional learning communities, grade- or subject level team leadership, committee leadership or other opportunities beyond the campus. |

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|---|---|---|---|---|---|
| | One-day PD opportunities; sporadically throughout the school year or during the summer | Attends required PLC opportunities | Participates in required PLC opportunities to develop and grow teacher practices | Participates in all PLC opportunities as a way to develop and grow teacher practices | Presents information during PLCs to peers to develop and grow teacher practices |

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## Appendix C

## Codebook for 21st Century Skills from Interview Data

| **Coded Constructs** | **Interpretation for Evidence of Understanding of Skill (1) (Non-existent receives a score of 0)** |
|---|---|
| Collaboration | Teacher demonstrated an understanding of the definition by applying to current practices |
| <u>Defined as</u>: the action of working with someone else in order to create something or produce something. | Gave an example of how this construct (based on definition) was part of their teaching practices |
| | |
| Creativity | Teacher demonstrated an understanding of the definition by applying to current practices |
| <u>Defined as</u>: the ability to convey information and ideas effectively by creating unique ideas and products | Gave an example of how this construct (based on definition) was part of their teaching practices |
| | |
| <u>Communication</u> | Teacher demonstrated an understanding of the definition by applying to current practices |
| <u>Defined as: The ability to convey information to another effectively and efficiently.</u> | Gave an example of how this construct (based on definition) was part of their teaching practices |
| | |
| Critical thinking | Teacher demonstrated an understanding of the definition by applying to current practices |
| <u>Defined as</u>: the application of knowledge and skills in practical ways to solve real world problems. | Gave an example of how this construct (based on definition) was part of their teaching practices |
| | |
| coherence (co) | All goals aligned to state content standards. |

| | |
|---|---|
| Defined as: ensures that there is a consistency within the school, district, and state reform policies to align | All activities, materials and assessments that: - are sequenced - are relevant to students - provide appropriate time for lesson and lesson closure - fit into the broader unit and course objectives - are appropriate for diverse learners |
| | |
| collective participation (cp) | Establishes classroom practices that provide opportunities for most students to communicate effectively with the teacher and their peers |
| Defined as: groups of individuals coming together with a common goal or purpose | Asks remember, understand and apply level questions that focus on the objective of the lesson and provoke discussion |
| | |
| content focused (cf) | Conveys accurate content knowledge in multiple contexts. |
| Defined as: demonstrating to the participating teacher the link between their content and the skills they are learning in order to make improvement | Integrates learning objectives with other disciplines. |
| | |
| active learning (al) | Engages all students in relevant, meaningful learning. |
| Defined as: characterized by methods other than listening to lectures, active learning can take a number of forms, including observing expert teachers or being observed, followed by interactive feedback and discussion | Students work respectfully individually and in groups. |
| | Provides students opportunities to take initiative of their own learning. |
| | |
| duration (du) | Collaboratively practices in all scheduled professional development activities, campus professional learning communities, grade- or subject-level team membership, committee membership or other opportunities. |
| Defined as: the amount of time, including both span of time over which the activity is spread, and the number of hours spent in the activity in order to bring about teacher change | Participates required PLC opportunities to develop and grow teacher practices |

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## Appendix D

## Audit Trail

The audit trail includes (1) the name of the original data source (e.g., interview, observation, document) and description (e.g., Teacher name, PLC document), (2) the location in the transcript where the evidence was found; and (3) the date the data was collected.

| Citation | Source | Location | Date |
|---|---|---|---|
| 1 | Classroom observation_Terrie | N/A | 10-22-2018 |
| 2 | Classroom observation_Haley | N/A | 10-15-2018 |
| 3 | Classroom observation_Martin | N/A | 12-14-2018 |
| 4 | Individual lesson plan | Lines 16-29 | 10-15-2018 |
| 5, 6 | Classroom observation_Terrie | N/A | 10-22-2018 |
| 7 | PLC lesson plans | Lines 39-45 | 11-15-2018 |
| 8 | PLC observation | Lines 10-20 | 10-19-2018 |
| 9 | Biology team lesson plans | Lines 30-38 | 9-17-2018 |
| 10 | Classroom observation_Claire | Lines 19-23 | 12-14-2018 |
| 11 | PLC observation | Lines 23-42 | 11-8-2018 |
| 12 | Classroom observation_Claire | Lines 25-31 | 11-12-2018 |
| 13 | PLC lesson plans | Lines 18-21 | 9-5-2018 |
| 14 | Classroom observation_Stacie | N/A | 12-14-2018 |
| 15 | Classroom observation_Stacie | N/A | 12-14-2018 |
| 16 | Classroom observation_Martin | N/A | 12-14-2018 |
| 17 | Classroom observation_Claire | N/A | 12-14-2018 |
| 18 | Classroom observation_Claire | N/A | 12-14-2018 |
| 19 | Classroom observation_Terrie | Lines 20-28 | 10-22-2018 |
| 20 | PLC lesson plans | Lines 16-17 | 9-10-2018 |
| 21 | Classroom observation_Claire | N/A | 11-12-2018 |

| | | | |
|---|---|---|---|
| 22 | PLC observation field notes | Lines 857-1121 | 9-27-18 |
| 23 | Observation field notes | Lines 17-20 | 10-18-2018 |
| 24 | Classroom observation_Terrie | N/A | 10-22-2018 |
| 25 | Classroom observation_Allison | N/A | 10-15-2018 |
| 26 | Observation field notes | Lines 29-39 | 9-17-2018 |
| 27 | Observation field notes | Lines 12-17 | 9-5-2018 |
| 28 | Observation field notes | Lines 26-27 | 10-18-2018 |
| 29 | Classroom observation_Raymond | Lines 9-11 | 10-15-2018 |
| 30 | Biology team lesson plans | Lines 39-45 | 11-15-2018 |
| 31 | Classroom observation_Allison | N/A | 10-15-2018 |
| 32 | Lesson Plans_Allison | Lines 15-18 | 10-9-2018 |
| 33 | PLC observation field notes | Lines 21-28 | 10-22-2018 |
| 34 | PLC observation field notes | Lines 36-41 | 10-22-2018 |
| 35 | Classroom observation_Bethany | N/A | 11-6-2018 |
| 36 | Classroom observation_Allison | N/A | 11-9-2018 |
| 37 | Classroom observation_Briana | N/A | 10-15-2018 |
| 38 | PLC planning agenda week 2.1 | Lines 52-53 | 9-15-2018 |
| 39 | PLC planning agenda week 2.2 | Lines 37-38 | 10-8-2018 |
| 40 | PLC observation field notes | Lines 18-19 | 10-22-2018 |
| 41 | PLC observation field notes | Lines 21-28 | 10-22-2018 |
| 42 | PLC observation field notes | Lines 36-41 | 10-22-2018 |
| 43 | PLC observation field notes | Lines 29-34 | 10-22-2018 |
| 44 | Classroom observation_Carla | N/A | 10-22-2018 |
| 45 | Individual lesson plans | N/A | 9-24-2018 |
| 46 | Individual lesson plans | N/A | 12-17-2018 |

| | | | |
|---|---|---|---|
| 47 | PLC lesson plans Nov 2nd - 16th | N/A | 11-12-2018 |
| 48 | PLC meeting minutes_school B | N/A | 10-24-2018 |
| 49 | Lesson plans Sept 17th - 28th | N/A | 9-27-2018 |
| 50, 51 | PLC planning agenda week 2.1 | Lines 52-53 | 9-15-2018 |
| 52 | PLC observation field notes | Lines 18-19 | 10-22-2018 |
| 53 | PLC observation field notes | Lines 21-28 | 10-22-2018 |
| 54 | PLC observation field notes | Lines 36-41 | 10-22-2018 |
| 55 | PLC observation field notes | Lines 29-34 | 10-22-2018 |
| 56 | Classroom observation_Allison | N/A | 11-9-2018 |
| 57 | Classroom observation_Briana | N/A | 10-15-2018 |