One Approach for Designing Differentiated Professional Development

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Abstract

This design-based research study describes the instructional design process, benefits, and lessons learned in providing District Science Coordinators (DSCs) with differentiated professional development. Two cohorts of DSCs participated in a two-year professional development (PD) program (12 in Cohort 1 and 11 in Cohort 2) that met synchronously once per month and assigned asynchronous modules to DSCs based on a pre-assessment performance. DSCs provided feedback for each module and the entire program through surveys and interviews. DSCs' engagement in the program was also tracked through the differentiated modules. DSCs' responses indicated that the PD program provided them with a community of practice and the knowledge, skills, and confidence to advocate for science education. Lessons learned throughout the process included that DSCs needed intermediate deadlines, modules needed to be divided into smaller topics, and more consistent feedback should be provided throughout the implementation. This study provides practical suggestions for designing differentiated PD programs for educators and offers a possible format to help create communities of practice for educators.

At its core, differentiation stems from the recognition that individual learners arrive in classrooms, each day, with ranging knowledge, lived experiences, abilities, ways of thinking, curiosities, and dispositions (Author, in review). A one-size-fits all approach to teaching and learning undermines the potential of all students to achieve successfully, yet we all struggle with how to inspire and meet the needs of individual students in our classrooms (Tomlinson, 2017). Similarly, we know that one-shot workshops, workshops where teachers attend a session one-time with no follow-up after, are less effective means for professional development (PD) (Desimone, 2009; Desimone & Garet, 2015). Yet, we continue to provide one-shot workshops to teachers (Banilower et al., 2018) and rarely, if ever, do we consider how PD delivered over long periods of time may need to be differentiated for teachers. We may differentiate by focusing on different content areas, grade levels, or contexts, but rarely do we take the time to look at what individual teachers or educational leaders need. Just like students, we need to consider the individual learning needs of teachers and educational leaders and seek to ensure these stakeholders get the right learning tasks at the right time (Earl, 2003).

As we continue to spend billions of dollars on PD in the United States each year (Credential Engine, 2021), it behooves us to attend to the design and implementation of effective PD. One area not explored extensively in the PD literature is the differentiation of PD for teachers and educators. To this end, our purpose was to explore the design of a differentiated PD program for district science coordinators (DSCs) and to provide one way others might approach the differentiation of PD in their context.

Many school districts employ a science curriculum director, such as a science coordinator, director of STEM education, or science supervisor. This individual is primarily responsible for coordinating science curriculum at the district or regional level and typically was a classroom teacher (Edmonson et al., 2012). Depending upon the school and district, DSCs may have partial or full responsibility for supporting science teachers in their districts or for selecting, designing, and/or implementing PD for teachers. These individuals have the potential to provide leadership in science education and play an important role in improving student achievement by working with teachers (Marzano et al., 2005). Unfortunately, they are often not prepared to assume this role, nor are there very many PD opportunities related to this role (Author, 2015). Often DSCs rely on their professional connections in order to improve their knowledge and skills (Author, 2017). The lack of DSC PD is underscored by the void in

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studies with this population and the lack of knowledge about the PD opportunities for DSCs (e.g., Kennedy, 2016).

In order to support DSCs in their work with teachers, we designed a year-long PD program embedded with differentiated PD opportunities. In this article, we describe two iterations of the differentiated PD, including the content covered, the implementation approach, and the feedback received. The purpose of this paper is two-fold. First, we hope to provide one example of how to design and implement differentiated PD for educators, teachers, and leaders, and to share lessons learned with others. Second, we wanted to know: What aspects, if any, of the differentiated PD support the learning and engagement of DSCs?

Conceptual Framework

Instructional design (Branch & Merril, 2011) and situated learning theory (Lave & Wenger, 1991; McClellan, 1996) were integrated and utilized as a conceptual framework to develop and design the differentiated PD. Below we describe each and how each was used in the study.

Instructional design is an approach to creating educational and developmental learning materials in a reliable way (Branch & Merril, 2011). It is an iterative process of considering outcomes, strategies for teaching and learning, selecting resources and approaches, and evaluating the results of a teaching and learning event. There is a focus on learning within a particular context as designers of instruction consider how best to structure and order learning events (Gagné et al., 2005). The instructional design process should be flexible enough to account for or respond to the complex nature of varying educational, teaching, and learning contexts (Branch & Kopcha, 2014). In this project, we took an instructional design approach based on Gagné and colleague's (2005) ADDIE model. In this model, there are clearly delineated components of Analysis, Design, Development, Implementation, and Evaluation; however, revision should occur within each step and the overall process may not be linear (Gagné et al., 2005).

Using this instructional design approach, we adopted situated learning theory as a means for thinking about how the DSCs enrolled in the PD would learn best. Situated learning theory suggests that learning occurs as individuals interact with their environment and others (Lave & Wenger, 1991; McClellan, 1996). The creation of new knowledge is recognized as a continual, highly situated and contextualized process. In this learning, the individual and the environment or context are not separate, but rather influence and construct one another (McClellan, 1996). Individuals are constructing and reconstructing their understanding of a concept and every experience they have shapes this construction and their understanding of that concept. The context includes the social, ethical, and historical norms, as well as the physical space and how these influence how people interact within their environment and with others. There are six key components of a situated learning model as identified by McClellan (1996): reflection, cognitive apprenticeship, collaboration, coaching, opportunities for multiple practice, and the articulation of learning skills. We worked to incorporate all of these elements into the design of the differentiated PD.

Review of Literature

There is little literature on differentiated PD; however, the literature on the characteristics of effective PD are extensive. Here we review the literature on effective PD by presenting seminal pieces and summarizing literature that is well established. Then, we examine the literature that does exist on differentiated PD and try to illuminate the gaps that currently exist in the research.

Effective Professional Development

There is agreement on the key components of PD that enhance teachers' knowledge, skills, classroom practices, and student achievement. These key components include content focus, active learning, coherence, duration, and collective participation (e.g., Desimone, 2009; Garet et al., 2001; Loucks-Horsley et al., 2010).

Content focus indicates the degree to which the activity is focused on improving and deepening teachers' content knowledge they taught (Garet et al., 2001). A focus on science-specific activities and content can improve teacher and student outcomes and be sustained following the PD (Heller et al., 2012). Embedding active learning opportunities in PD enable teachers to become actively involved in the sense-making of their teaching and learning. These activities can include reviewing student work, observing teachers, and receiving feedback on their teaching progress (Desimone, 2009). Active learning is also an "umbrella" component in PD that often includes elements such as collaboration, coaching, feedback, reflection, and the utilization of models and modeling (Darling-Hammond et al., 2017). Coherence is considered the degree to which the activity in PD programs offers learning opportunities that are consistent with teachers' goals and aligned with local, state, and national standards (Desimone, 2009; Garet et al., 2001).

Duration describes the number of hours spent performing the activity as well as the time period during which the activity occurs (Desimone, 2009; Garet et al., 2001). A sustained duration of PD is required for meaningful PD, quality implementation (Darling-Hammond et al., 2017), and teacher change (e.g., Garet et al., 2001). Research does not specify a required duration, but it does encourage activities that last a semester (or intensive summer institutes with follow-up during the semester) and contain 20 hours or more of contact time (Desimone, 2009). Finally, collective participation is the extent to which an activity emphasizes the collective participation of groups of teachers from the same school, department, or grade level, as opposed to the engagement of individual teachers from many schools (Garet et al., 2001). During the development of the PD program, the instructional design process worked to align the characteristics of effective PD with situated learning theory while also considering how the PD program could be differentiated.

Differentiation in Professional Development

Though we understand the characteristics of effective PD, we also recognize that there are other factors that influence

whether teachers learn from and implement what they learn in PD. One of these factors is whether the PD is differentiated. However, there is little literature examining differentiated PD, so here we begin examining how differentiation is viewed in the classroom and then examine the sparse literature that does exist.

Students bring their interests, culture, and educational background to classrooms. To meet these diverse students' where they are and to address their needs, teachers need to differentiate their instruction (Parsons et al., 2013). In educational literature, planning is the foundation of differentiated instruction, and this first step allows teachers to plan their instruction strategically to meet the needs of diverse students (Parsons et al., 2013). During the planning of differentiated instruction, teachers use various formal and informal assessments to make informed instructional decisions. They consider how students learn and are reflective to observe their students' progress to make immediate instructional changes or to plan future interventions (Parsons et al., 2013). Researchers describe differentiated instruction as an individualized teaching and learning process based on the learner's prior knowledge and abilities, developmental readiness, interests, and learning preferences (e.g., Bowgren & Sever, 2010; Grierson & Woloshyn, 2013; Tomlinson, 2003). Teachers use multiple pathways and techniques, such as offering content with effective practices, engaging students in learning, and providing learning materials and products to maximize student learning (Grierson & Woloshyn, 2013; Parsons et al., 2013; Smutny, 2003).

Like students, teachers come from various educational backgrounds, cultures, and have different interests and needs. Many researchers indicate that a one-size-fits-all approach to PD is unproductive in increasing teacher capacity and participation in professional learning (Darling-Hammond & Richardson, 2009; Gabriel, 2010; Garet et al., 2001). Differentiated PD programs are one way to address the diverse needs commonly found within school systems (Gabriel, 2010; Kose, 2007). In planning a differentiated PD program, assessing the individual needs of PD participants is a foundational first step (Bowgren & Sever, 2010; Sweeny, 2003). For example, PD for educators may be differentiated by grade level, department, years of experience, or other pertinent factors to the PD topic (Kose, 2007; Lentz, 2013).

There is little research on how differentiated PD programs might be implemented for teachers and no research, that we could find, discuss differentiating for educational leaders. One approach often taken by schools or districts offering PD is to provide a menu style of PD options for teachers to choose from (e.g., Bates et al., 2018). While this may seem an easy and effective way of differentiating PD, doing so may not lead to a coherent program because teachers do not choose options aligned to their needs or to the greater school vision (Gabriel, 2010). The problem then becomes how to differentiate PD for teachers in an effective and efficient manner. Again, the research in this area is meager, but there are some studies that have attempted to study the differentiation of PD for teachers.

In one such study, the PD was differentiated by years of experience and it resulted in improved teaching expertise and the increased retention of teachers in their first three years (Gabriel, 2010). This case study with six teachers showed that teachers need different kinds of support to grow professionally in terms of their years of teaching experience. For instance, first-year teachers needed colleagues' support more than second and third-year teachers. Thus, planning more learning opportunities for teachers to collaborate with colleagues for first-year teachers in a PD might be critical to supporting their professional growth.

In a review of high performing school systems, Jensen and colleagues (2016) examined how four different systems designed and implemented PD. Results indicated that these systems recognize effective PD as the most important driver of student learning and understand PD needs to be differentiated to meet the individual needs of their teachers. For example, every teacher in Singapore receives a personally designed Individual Learning Plan that is aligned to department and school goals and based on a teacher's developmental needs, strengths, areas of improvement, and current placement. Another common characteristic of these high performing systems was that PD was differentiated by subject specific content and guided by system leaders of the content groups (Jensen et al., 2016).

Summary

In summary, the literature provides clear evidence of what characterizes effective PD, but provides few examples of how to differentiate PD for teachers. However, the literature seems to agree that differentiation of PD may be one way to meet the diverse needs of teachers and impact student achievement (e.g., Gabriel, 2010; Jensen et al., 2016). Further, we found no studies that differentiate PD for educational leaders and administrators. This study begins to fill this gap in the literature by providing a detailed example of how one program differentiated online PD.

Methods & Results

This exploratory project utilizes a design-based research approach (The Design-Based Research Collective, 2003). The design-based research approach strives to build a high-quality PD program by enacting continuous cycles of design, implementation, analysis, and redesign during the development and enactment of the program. Given this research approach, we describe the methods and results together describing the context, the implementation of the differentiated component of the PD program with two different cohorts, the feedback received, and the revisions made as a result (Alghamdi & Li, 2013; Collins et al., 2016). We hope these descriptions may provide insight into how you might design differentiated PD programs for educators. In addition, we hope others may be able to learn from and build on our experience.

Context for Implementation of Differentiated Professional Development

The current study was part of a larger study focused on building the leadership capacity of DSCs. There are two

groups of DSCs in the study: one group is engaged in a yearlong PD program, while the other is a "business as usual" group (no professional learning). As part of the larger study, DSCs participated in monthly synchronous sessions of various lengths over a 9-month period. During three of the 9 months, the synchronous sessions occurred over three evenings for 2-hours each evening. During the other six months, synchronous sessions were just one 2-hour session one evening. At the same time, DSCs were also assigned differentiated, asynchronous modules. The overarching topics identified for inclusion in the asynchronous modules were a) implementing 3D instruction and the science practices, b) curriculum alignment, and c) supporting the professional learning of teachers. These topics were identified from previous work with DSCs and examining the literature for common needs in science education. Also embedded in each module was a focus on equity. Within each module, there were opportunities to analyze videos, examine data, read research, participate in discussions, and work on a final end product or application task. The current study focuses specifically on the asynchronous 3D modules provided to the DSCs engaged in the yearlong PD program that were differentiated based on readiness. DSCs completed a pre-assessment to determine what asynchronous modules they would be assigned to take. This is described in more detail below.

Year 1 Iteration

In the first year there were 12 DSCs in the program. They ranged in assignment from being the only DSC in their district to working as part of a two-person team in their district. Most were from suburban school districts. The largest school district had 130 schools, while the smallest school district had seven schools. Among the DSCs, eight were female. The DSCs had an average of 18 years in education, and 4.5 years in their current leadership position. Nine of the DSCs had four or fewer years in the position. Regarding their professional responsibilities, 6 were responsible for K-12 science education, while the rest were responsible for secondary level (4) or elementary level science education (2) specifically.

During the first year, there were three differentiated modules assigned to DSCs based on their pre-assessment: Professional Learning Programs, Coherent Curriculum, and Equitable 3D Science Instruction. Below we describe the pre-assessment DSCs completed, the content of the modules, the implementation of the modules, and the feedback received.

Pre-Assessment

Each participating DSC completed a pre-assessment about their knowledge of equitable science instruction, creating coherent curriculum, and designing professional learning programming. The pre-assessment included 10 items for each of the three areas for a total of 30 items. The assessment included items from published materials, and newly written items. The questions included multiple choice, matching, open-ended, sequencing, reporting, andscenario items. The pre-assessment was reviewed by a panel of teacher educators and former science teachers for face and content validity and went through three rounds of revision (Haynes, Richard, & Kubany, 1995). The different assessment items were scored using a developed answer key as either correct or incorrect. As correct answers existed, items were scored by only one coder.

After evaluating their pre-assessment, if a DSC scored correctly on 8 out of 10 items (80%) for a module then the module was made optional for that DSC. If a DSC scored less than 80% on the pre-assessment for a module, then it was determined that the DSC may need to refresh their thinking and/or dig deeper into the topic. As a result of the scoring, six DSCs were assigned the Equitable 3D Science Instruction module, five DSCs were assigned the Coherent Curriculum module, and all 12 DSCs were assigned the Professional Learning Programs module (Table 1). DSCs had the option of doing additional modules, but none of these DSCs chose to complete a module that was not required.

Content

The content of the three asynchronous differentiated modules is described below and summarized in Table 2.

Professional Learning Programs. The Professional Learning Programs (PLP) module contained seven submodules to assist DSCs in developing effective professional learning programs for teachers. The PLP module focused on what elements contribute to successful professional learning and how these design features could be included in PLP to help all teachers. DSCs viewed several brief videos about the characteristics of successful PLP and read recent research on effective professional learning practices. Next, the module provided information on how to differentiate professional learning for teachers' needs. DSCs again watched short videos and read articles before sharing their experiences facilitating professional learning. Following that, the module explained how to evaluate PLP. DSCs used different evaluation models to evaluate their own PLP sessions and shared their results.

Coherent Curriculum. The coherent curriculum module consisted of seven submodules, including the introduction and conclusion. The goal of this module was to learn what makes curricula good, how to consider multiple orientations in science curricula, and how to foster diversity in the classroom. DSCs were able to identify essential aspects of well-designed and aligned curriculum and instructional materials using rubrics and standards as a result of the practices in this module. At the end of the module, DSCs completed curricula maps and

Table 1. Assigned and completed modules for Year 1

Module	Number of DSCs Assigned	Number of DSCs Completed
Equitable 3D Science Instruction	6	6
Coherent Curriculum	5	5
Professional Learning Programs	12	12

ensured the maps were aligned to state standards and were vertically and horizontally coherent.

Equitable 3D Science Instruction. The Equitable 3D Science Instruction module was made up of ten submodules, including the introduction and conclusion. This module sought to support DSCs in designing PD around equitable 3D science instruction. This module included activities such as comparing traditional and equitable 3D science instruction, addressing race, gender, and cultural differences in science instruction, assessing student learning, and analyzing student data to inform equitable 3D science instruction. DSCs developed a PD plan to deliver a PD session on equitable 3D science instruction at the end of the module.

Year 1 Implementation and Completion

After completing the pre-assessment, DSCs received their assigned modules via email and were asked to complete these modules by the end of the academic year. DSCs were provided regular reminders to be working on modules throughout the year at every synchronous PD session.

Figure 1. Timeline of module completion

The modules were not assigned in any particular order and DSCs could complete the modules in any order they preferred. A heat map was generated showing when DSCs spent time working through the modules (Figure 1; pseudonyms are used). The majority of the DSCs completed modules by the final deadline, but as is evident from the heat map most waited until the final deadline (May 2021) to complete. Despite having 8 months to complete the modules, many completed them in a short span of time rather than spreading out completion over time. And, a few even needed the deadline extended to complete the modules. At the May 2021 synchronous PD session, DSCs were provided an opportunity to discuss their learning from the modules. DSCs were broken up into small groups to hold these discussions and were provided guiding questions depending on the modules they completed.

Year 1 Results

Researchers used descriptive coding to create summary codes from DSC feedback (Miles, et al., 2018). This first

Table 2. Year 1 module content and final products

Module	Content of the Module	Final Product
Professional Learning Programs	1. Introduction to module 2. What is the role of professional learning in teacher growth? 3. How do we support teacher learning? 4. What makes professional development programs good? 5. What makes professional learning programs good for all teachers? 6. What makes for a good professional learning facilitator? 7. How do we ensure a professional learning program is good? 8. What is the future of good professional learning programs? 9. Conclusion of module	Design of a Professional Learning Program with Evaluation
Coherent Curriculum	1. Introduction to module 2. What makes the curriculum good? 3. What are the different orientations towards curriculum (Science Focus)? 4. What are the different orientations towards curriculum (Other perspectives)? 5. How do we identify good curriculum and/or instructional materials? 6. How do we ensure curricular coherence and design curriculum? 7. Conclusion of module	Curriculum Map and Evaluation of Curriculum
Equitable 3D Science Instruction	1. Introduction to module 2. What is 3D Teaching? 3. How Does 3D Teaching Differ from Traditional Instruction? 4. How Can Phenomena Drive Instruction? 5. How Do Students Learn? 6. How Do We Address Racial and Gender Equity When Teaching Science? 7. How Do We Address Cultural Differences When Teaching Science? 8. How Do We Assess Student Learning in the Midst of 3D Instruction 9. How Do We Analyze Student Data to Inform Equitable 3D Instruction? 10. Conclusion of module	Design of Professional Learning Program around equitable 3D instruction.

cycle of coding involved two researchers reading the feedback and coding the responses based on the topic or issue discussed. These codes summarized the topic discussed and researchers met to compare codes and reach agreement through discussion on any discrepancies. Next, codes were analyzed to find patterns within the data to help determine the degree to which participants felt the materials and activities embedded in each section of the modules helped participants meet their professional learning needs. Patterns that emerged from this first year of data included: alignment with needs/goals, content issue, technology tools, designing PD, diverse learners, alignment with district concern, and module structure.

In general, most of the feedback received was positive, and participants indicated they found most of the activities and materials to be aligned with their needs and goals. In cases where participants left negative feedback, the comments centered on a particular video or article that the participants did not find useful or that did not align with their needs and goals. In some cases, participants left conflicting feedback around particular technology tools, such as Jamboard or FlipGrid. Some participants enjoyed using the new tool and wanted to share it with their teachers, while others felt that its inclusion was "technology for technology's sake".

Reading and practicing the principles of designing and implementing effective PD as well as the primary outcomes of each part in the PLP module helped them design good PD for their teachers. One DSC revealed: "Creating the professional development model was very useful as I reflected on what components help with sustainability and the effectiveness of teaching and learning." It was clear that this module helped them think about what needed to happen in their district and when they were designing PD for their teachers.

DSCs also gained insight about teaching diverse learners from articles and videos regarding equity and diversity in the Coherent Curriculum module section. In this module, they practiced coherent curriculum mapping, which helped them discover the elements of effective curriculum design. Their current curriculum development procedures were expanded through the use of new tools and rubrics to evaluate educational resources.

Sections that received the most positive feedback often mirrored issues or concerns that DSCs had about their own work or district and allowed them to brainstorm or role play how they would tackle the issue in their context. A section of the Equitable 3D Science Instruction module asked DSCs to examine case studies of teachers in a hypothetical district. One participant wrote:

> I actually enjoyed reading through the case studies - the elementary one made me depressed (I think because it mirrors what I see in my district); however, the middle school one was exciting as it gave me vision of what I would hope to see in the future.

Another said:

> Reading through the case studies was extremely useful. It allowed me the opportunity to reflect on what my teachers/schools would say. It helped to identify common obstacles and begin to brainstorm potential solutions.

Some overarching feedback from the DSCs about module structure suggested that the module overviews at the beginning of each module were appreciated by DSCs and helped them to focus on what might be important within the module. Additionally, DSCs suggested that the length of modules were an issue and that having interim deadlines would have been helpful for completing the assigned modules in a timely manner.

Year 2 Iteration

In the second year there were 11 DSCs in the program. They ranged in assignment from being the only DSC in their district to working as part of a two-person team in their district and working only with science to working with multiple subject groups. Five of the DSCs worked in suburban districts while the other six DSCs were divided equally between cities and rural districts. The districts ranged in size from three schools located in one suburb to 244 schools across an entire county. Nine of the DSCs identified as female and two identified as male. Their experience in education ranged from 12-28 years with an average of 20 years. Their experience as a DSC ranged from 0.5-15 years and nine of the DSCs had less than four years in the role. Regarding their professional responsibilities, four were responsible for K-12 science, three were responsible for 6-12 science, and one each was responsible for K-5, K-8, 3-12, or 9-12.

Based on feedback from the first year about the length of the modules, the three differentiated modules were split into seven smaller modules to decrease the length and time of completion and interim deadlines were assigned for each module. The differentiated modules that DSCs could be assigned based on their pre-assessment for year two were: Implementing 3D Science Instruction, Moving Toward Equity, Assessing and Analyzing Student Learning, Supporting Student Learning, Designing Professional Learning, Developing and Evaluating Coherent Curriculum, and Exploring Orientations to Curriculum. Negative feedback received during Year 1 also informed changes to content (e.g., articles or videos used) and technology tools used. Below we describe the pre-assessment DSCs completed, the content of the modules, the implementation of the modules, and the feedback received during the second year.

Pre-Assessment

The pre-assessment from the first year was modified to ensure each of the new modules had equal number of questions. This version of the pre-assessment included 35 items with five items for each of the seven areas. The assessment included the items from the previous version and added newly written items to ensure there were equal numbers of items for each module. The questions again included multiple-choice, matching, open-ended, sequencing, reporting, and scenario items. Again, the assessment was reviewed by a panel of science educators and former teachers in science education for face and content validity

Table 3. Assigned and completed modules for Year 2

Module	Number of DSCs Assigned	Number of DSCs Completed
Implementing 3D Science Instruction	7	7
Moving Towards Equity	5	7
Assessing and Analyzing Student Learning	9	9
Supporting Teacher Learning	9	8
Designing Professional Learning Programs	11	9
Developing & Evaluating Coherent Curriculum	3	5
Exploring Orientations to Curriculum	11	9

and two rounds of edits occurred (Haynes, Richard & Kubany, 1995). The different assessments were scored using a scoring key.

After evaluating their pre-assessment, DSCs were assigned the modules as described in Table 3. If DSCs scored 80% or better (4/5) they were not required to take a module. Some DSCs chose to complete additional modules because they were interested in the topic and/or they felt it might benefit their practice.

Year 2 Implementation Changes

Feedback from the first cohort suggested the need to break the modules into smaller parts and to have interim deadlines. Given this, the three modules were divided into seven smaller modules as described in Table 4. The modules covered the same content, but had different final products than the Year 1 modules. Some revisions were also made to resources based on feedback in terms of articles that needed to be shortened or the removal of items that did not feel useful to the DSCs. To address the timely completion issue experienced by Cohort 1, DSCs were given deadlines for each module with each one due approximately one month after the previous one.

Table 4. Year 2 module content and final products

Module	Content of the Module	Final Product
Implementing 3D Science Instruction	1. Introduction 2. What is 3D teaching? 3. How does 3D teaching different from traditional instruction? 4. How can phenomena drive instruction? 5. Wrapping it up	Assess current teachers positions on 3D science instruction
Moving Towards Equity	1. Introduction 2. How do we address racial and gender equity when teaching science? 3. How do we address cultural differences when teaching science? 4. Wrapping it up	Create professional development plan to increase teacher knowledge about equity and culturally responsive teaching
Assessing and Analyzing Student Learning	1. Introduction 2. How do students learn? 3. How do we assess student learning in the midst of 3D instruction? 4. How do we analyze student data to inform equitable 3D instruction? 5. Wrapping it up	Create plan to move towards research-based best practices for student assessment
Supporting Teacher Learning	1. Intro 2. What is the role of professional learning in teacher growth? 3. How do we support science teacher learning? 4. What is the future of good professional learning programs? 5. Wrapping it up	Create plan for serving teachers needs based on module
Designing Professional Learning Programs	1. Introduction 2. What makes professional development programs good? 3. What makes professional learning programs good for all teachers? 4. What makes for a good professional learning facilitator? 5. How do we ensure a professional learning program is good? 6. Wrapping it up	Create professional development plan based on module
Developing & Evaluating Coherent Curriculum	1. Introduction 2. What makes curriculum “good”? 3. How do we identify good curriculum and/or instructional materials? 4. How do we ensure curricular coherence and design curriculum? 5. Wrapping it up	Use the EquIP rubric to evaluate curriculum
Exploring Orientations to Curriculum	1. Introduction 2. What are the different orientations towards curriculum (science focus)? 3. What are the different orientations towards curriculum (other perspectives)? 4. Wrapping it up	Develop a professional development session pertaining to curriculum orientations

After completing the pre-assessment, DSCs received their assigned modules via email and were asked to complete these modules by clearly stated deadlines. Each deadline corresponded to a synchronous session. Reminders were provided at each synchronous session and emails were sent following the synchronous session to remind those who were assigned the next module of the need to complete it. In contrast to Year 1, the modules were assigned in a particular order and at the end of each synchronous session thirty minutes were dedicated to discussing the module due for that day. DSCs who were not assigned the module were not required to stay for the module discussion but had the option of attending if they were interested in the topic and discussion. A heat map was generated showing when DSCs spent time working through the modules (Figure 2; pseudonyms are used). From the heat map it is evident that DSCs worked more consistently throughout the year to complete their modules by the assigned deadlines. For the most part, DSCs completed the modules on time with few needing extensions. Only three needed additional time and these were for health and/or extenuating circumstances.

Table 5. Year 2 module feedback questions

Likert Questions	Open Ended Questions
I enjoyed this module.	How might you use what you learned in this module in your own work?
The material was important and relevant.	What about this module, if anything, did you find difficult or challenging?
The module met my needs and expectations.	If you were describing the value of this module to a colleague, what would you say about why they should participate?
This module was worth my time.	If you have any suggestions for changes or concerns regarding this module, please share them here.

Year 2 Results

Similar to Year 1, DSCs provided feedback on each module by responding to a survey upon completion. However, in Year 1 these surveys included only open-ended questions which became onerous for participants. In Year 2, this feedback survey was modified to include four Likert questions asking them to rate the aspects of each module on a scale of strongly disagree to strongly agree. They also responded to the same four open ended questions as Year 1, but responses on these questions were not required and were only asked once at the end of a module. Feedback questions can be seen in Table 5. Participants also provided End of Year feedback on all aspects of the PD program through a final survey and end-of-year interview. Patterns that emerged from the second year of data included: stress, time, length, content interest, equity issues, new knowledge/skills gained, peer network, and active participation.

Overall, feedback from the Likert Scale questions (Table 5) was overwhelmingly positive, in that all but two responses in total were strongly or somewhat agree. Negative feedback from DSCs communicated the stress they were under from their job and not having enough time to complete the module. For example, when asked what they found difficult or challenging about a module, Margo said, "The amount of work involved in all the modules. It is just a lot. I have trouble keeping up with all the work." This was similar to other negative comments left by DSCs. The new seven module layout asked DSCs to complete one module per month, if assigned. Many DSCs found their district work to pick up between February and May, some also had extenuating life circumstances, and they fell behind in the module work during these months. Overall, they did not note other negative issues with the modules.

The positive feedback received reflected the individuals interest in each module. For example, participants noted how the module influenced their work in planning PD with teachers and considering their work before, during, and after the PD. For example, one participant wrote: "Being deliberate and intentional in designing professional learning is important and worth the dedication to time and proper planning – I will be mindful of this moving forward!" Like

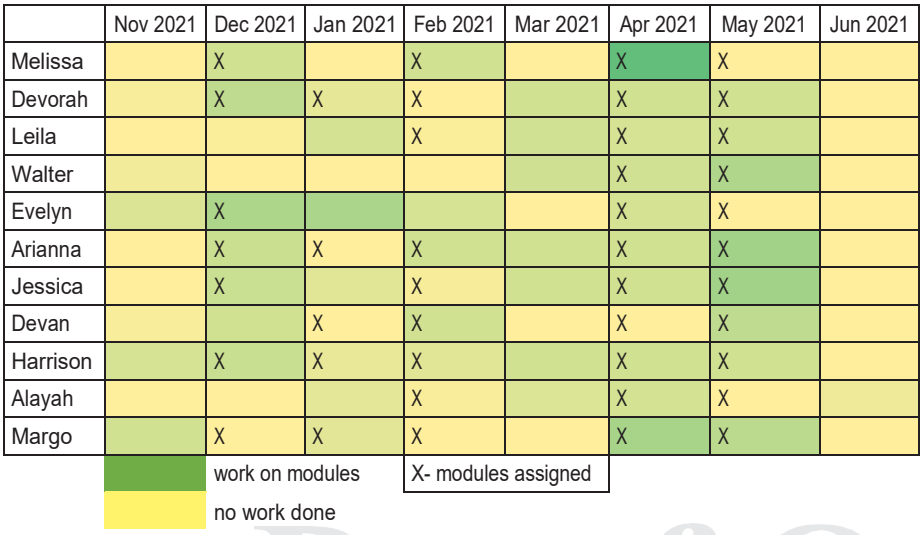

Figure 2. Timeline of module completion

this DSC, many saw value in the *Designing Professional Learning Programs* module and were considering how they would enact what they had learned moving forward. Similarly, another DSC noted: "This module gave me a lens from which to assess PD sessions before implementing them to assure they will most likely be effective and meet the needs of teachers."

DSCs also gained insight about equity issues within the science curriculum. DSCs created a PD session centered around the null and hidden curriculum in science as a culminating product for the *Exploring Orientations to Curriculum* module. This topic was new to many DSCs and they reflected on their work toward improving teacher knowledge to support all students. One DSC noted: "I will use this information to further help me develop materials and trainings that will allow me to coach teachers in the value of culturally relevant teaching and curriculum." Another DSC noted a lack of knowledge in this area. "I guess I have never really thought about all three types of curricula. ...this will be good information as I work with teachers." Feedback noted the opportunity to learn and be challenged in new ways: "This module was my favorite so far because it challenged me to consider things I had not considered before." Other DSCs had similar responses to these for this module.

Overall feedback across the modules indicated that DSCs were recognizing the need for the knowledge and skills embedded in the modules. Some participants explained this need by noting the differences in expectations and job skill requirements as they changed roles through their career. For example, one DSC said: "Changing from a teacher to an instructional or district leader requires more than just knowledge of content and instructional strategies. We need an understanding of adult learning and the different methods of presenting professional development." Given these responses, the modules appear to be meeting some of the DSCs' needs.

DSCs also offered feedback that highlighted their appreciation for developing new skills they acquired and feelings of confidence, validation, and motivation to create change in their contexts. For example, when describing a benefit of the PD program, one DSC stated, "How to plan for specific needs, how best to map out effective PD that will move the teachers to the new standards." This quote shows how the DSC developed knowledge and/or skills to strategically plan PD. Others described a benefit of the PD program of being able to plan strategically and to align PD to a broader vision. This implies that prior to participating in the PD project they were developing PD that was not systematically planned and/or aligned to a broader vision. The PD program also impacted DSC confidence as can be seen in this response, "Essentially it has put a battery in my pack as far as being confident in my assertion about what science education needs in our district." Similarly, multiple DSCs reported feeling more confident in the work they do with teachers.

At the end of the year DSCs also noted an appreciation for the created network of people in similar roles to talk with during the program. Some DSCs reported reaching out to peers from the program for support while others said they had not worked with the other DSCs outside of the PD activities. Two representative responses about working with other DSCs included, "I really enjoy the people in the group and value their options." and, "true fellowship and intellectual discourse! Amazing!" Three DSCs mentioned that they had met with other DSCs from PD program outside of typical meetings for support on job-related issues such as textbook adoption, to share professional learning plans, and how to provide PD to administrators. Other DSCs had not met with other DSCs outside of the program, but felt comfortable to do so in the future.

Lastly, the participants described how they were treated as equals in their learning through the PD program which is not something they have always felt in other professional learning opportunities. One quote that represents DSCs' responses was, "As I mentioned above, being a part of the conversation as opposed to just an attendee makes a huge difference in the impact it has on me professionally." This demonstrates that DSCs felt respected as professionals throughout the PD program and that their knowledge and experiences were valued.

Lessons Learned

After implementing two iterations of the differentiated PD program for DSCs, the project team took away some key lessons learned that we feel may support others in the design and implementation of other differentiated PD programs for educators. First, we found that the pre-assessment was an effective method for assigning DSCs to modules that met their learning needs. Determining the participants' learning needs before the modules' implementation allowed us to effectively determine what modules would best support each DSC.

The most important logistical lesson we learned was that the original three asynchronous modules needed to be broken down into smaller modules with their own due dates as opposed to all being due at the end of the school year. Doing so helped the participants manage their time as can be seen by the difference in Figures 1 and 2. When the modules were all due in May, Cohort 1 completed a significant portion of the work in May, but when modules were due throughout the year for Cohort 2, the work was completed throughout the year. Along with creating more manageable chunks of work, dividing the three original modules into seven smaller ones allowed for meaningful synchronous debriefs after each module was due. The more frequent due dates also meant that all DSCs assigned to a given module were working on it at approximately the same time, so they had the opportunity to debrief the module as an entire group or reach out to one another while completing it. It also meant that the discussion board responses built into the module were more interactive as they were engaging at the same time. According to the DSCs feedback, asynchronous modules with synchronous debriefs were more potent

than just attending the asynchronous modules alone.

Finally, we saw that the Cohort 2 DSCs used the resources provided in the modules when supporting their teachers. The modules included many resources, including videos, research articles, practitioner articles, case studies, and other activities related to the content of the module. Many DSCs in Cohort 2 said they used these resources when working to support their teachers on the topics covered by the modules. The fact that we did not see this with Cohort 1 might suggest that the shorter modules provided more time for DSCs to digest the material and consider how the content might apply and/or be used in their own contexts.

Limitations

While the feedback of the DSCs was quite positive, there is at least one limitation of this study. The DSCs provided positive feedback, but at this point it is unclear if the PD program has improved their work as a DSC to improve teacher effectiveness and ultimately improve student learning. Over the course of the next two years the research team will continue to interview teachers that work under these DSCs to better understand the impact of this PD model on DSC practices and their work with teachers.

Discussion

The purpose of this paper was two-fold. First, we wanted to share an example of how to design and implement differentiated PD for educators and to share lessons learned through the process. The model of PD described in this paper was designed using best practices for PD such as coherence, duration, and active learning (Desimone, 2009; Garet, 2001) and differentiated to meet the diverse learning needs of the participants. In addition, the PD provided the opportunity for DSCs, who are often on their own to think about science at the central office, to engage in a community of practice. Second, we wanted to understand what aspects, if any, of the differentiated PD supported the learning and engagement of DSCs. In considering the design of differentiated PD, we believe it was the synergy between the design components and 1. the differentiation of the modules, and 2. the ways DSCs were engaged that supported this model of PD. Here we describe how these components interacted to increase the engagement and learning opportunities for DSCs.

Design (Coherence) and Pre-Assessment Differentiation

Feedback from the DSCs on the individually assigned modules provided evidence that the differentiated aspect of this PD model supported the learning and engagement of DSCs. By using a pre-assessment to determine which science education leadership domains the DSCs had limited knowledge about we were able to assign them asynchronous learning modules targeted to their needs. This allowed us to provide PD options to fill their professional knowledge gaps as opposed to asking the DSCs to make choices based on their individual preferences, which may have not filled their knowledge gaps (Gabriel, 2010). Utilizing a pre-assessment to determine the PD participants engage in may be more effective than providing a menu of options (e.g., Bates et al., 2019) when designing differentiated PD and this study provides one example of how that may be enacted.

The content of the asynchronous modules was developed with the unique needs of DSCs in mind. DSCs need science education specific knowledge and skills as well as educational leadership knowledge and skills (e.g., Author, 2019; Author, 2022). From that perspective, all modules could have been considered coherent for all DSCs. But by administering the pre-assessment, it was revealed that DSCs had varying degrees of knowledge related to the content of the modules. If DSCs were asked to complete all of the modules, then some DSCs would have been just reviewing content they already had sufficient knowledge of rather than investing their time in areas where they needed to grow. This would have been an inconsiderate and misuse of the DSCs time. Likewise, if the PD had been implemented using a menu-style approach, DSCs, like teachers often do (Gabriel, 2010), may have just selected PD they were interested in and that wasn't necessarily filling a gap in their knowledge. Through the differentiation of the modules using a pre-assessment, DSCs were able to have a more coherent experience in the PD. To our knowledge, using pre-assessment as a means for differentiating educators' PD has not been presented in the literature and is a contribution of the current study.

Design (Active Learning) and Collaboration

Many districts only employ one DSC or if they have multiple, they often work at different grade levels. This means that DSCs are often isolated in their roles and their learning is often not rooted in science in these contexts (Author, 2019). By designing the modules to support active learning (e.g., asking DSCs to reflect, engage in discussions, and develop artifacts), the DSCs were able to engage with others who served in similar roles. Situated cognition (Lave & Wenger, 1991) describes how the interaction between colleagues, the activities they engage in, and the resources they use influence what is learned. The asynchronous modules could have been implemented without interaction (and mostly were for Cohort 1), but this ignores the social side of learning. Providing DSCs with the time, space, and activities to engage with each other gave them the opportunity to learn with and from each other. This provides some initial evidence that PD differentiated for specific content areas and grade levels may provide opportunities for educators that they aren't otherwise offered. It may be that other content specific district coordinators (e.g., English, Math, Social Studies, Health & PE) may also benefit from opportunities to learn with those in their content area and in similar leadership roles.

Summary

The interaction between characteristics of effective professional development described in previous research (e.g., Desimone, 2009; Garet, 2001) and differentiating the content of PD based

on DSC needs through the use of a pre-assessment helped to support the learning of the DSCs in this project. Differentiating the content of the PD allowed for a more coherent PD program in which DSCs could actively engage with others in similar roles.

Given the limited research on differentiated PD, this work begins to fill a gap and perhaps point a way forward for doing this work. There are three main things we can learn from this study. First, it is evident that it's possible to differentiate PD for adult learners and while much of the work around differentiation is for K-12 students, this may be an area that is needed and should be pursued in education. Second, when differentiation of PD is mentioned, many teacher educators and/or PD facilitators don't know where to start with designing differentiated PD. This exploratory study provides one-way facilitators may consider designing PD and highlights that differentiation doesn't necessarily mean that you must design something different for each individual. It suggests designing PD, pre-assessing participants, and assigning PD sessions based on gaps in participants' knowledge or skills may be one way to implement differentiated PD. Again, this is one approach to differentiation, but may be a promising one that can be scaled for larger groups. Third, by implementing differentiated PD, the learning opportunities took on more coherence for the participants because they were engaging with topics, they needed to learn more about or developing skills they needed. And, by designing the sessions to be more active, as we did for Year 2, we were able to promote more collaboration and peer networking that promoted participants learning. Using the findings and lessons learned from this study, teacher educators and PD facilitators may be able to begin considering how they could differentiate PD for their participants.

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