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Article

"Assessment as Discourse": A Pre-Service Physics Teacher's Evolving Capacity to Support an Equitable Pedagogy

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Abstract: One way to view 'equitable pedagogy' is through an opportunity to learn (OTL) lens, meaning that regardless of race, class, or culture, a student has access to rigorous and meaningful content, as well as appropriate resources and instruction necessary to learn and demonstrate understanding of that content. Assessment holds a unique position in the classroom in that it can both uncover whether inequitable conditions exist (*i.e.*, performance gaps, denied OTL) and provide an OTL by mediating communication between teacher and students regarding learning progress and what is important to learn. Nevertheless, individuals entering teacher education programs often hold deficit views toward marginalized students, such as Language Minorities (LMs), believe that assessment strictly serves to evaluate learning, and do not do consider how language and culture influence student thinking–views supplanting assessment's role at supporting an equitable pedagogy for LMs. Through surveys, interviews, program artifacts, and classroom observation, I report on a case study of one pre-service physics teacher, Dean, to depict how his expertise at assessing science did evolve throughout his yearlong teacher education program in terms of (a) becoming more knowledgeable of the role of language and (b) developing a belief in incorporating 'discourse' while assessing science. Within the case study, I analyze one particular episode from Dean's teaching practicum to highlight remaining challenges for pre-service teachers to integrate science and language in classroom assessment—namely, interpreting students' use of language *along with* their understanding of core science ideas. The findings underscore the need for connecting language and equity issues to content-area assessment in teacher preparation.

Keywords: assessment; equity; language minorities; science education; teacher education

1. Introduction

Entering teacher education programs, individuals often hold deficit beliefs about marginalized students, including students whose first language differs from the one used to instruct (referred to language minorities (LMs) throughout this paper). In particular, content area (social studies, science, mathematics) pre-service teachers might be unaware of how culture and language influence learning, might perceive LMs as less capable learners than non-LMs, and might not consider multicultural teaching (including teaching language) as their responsibility [1]. In science education, deficit views about teaching language may be particularly problematic given increased emphasis on promoting literacy and discourse (e.g., explaining and arguing) in science [2]. The United States' Next Generation Science Standards [2] and Common Core State Standards for English Language Arts [3] couple literacy practices with content learning. Yet, most teacher education programs, as currently structured, do not help new teachers develop the knowledge and dispositions needed to meet the learning needs of LMs [4,5]. For one, content method courses rarely promote valuing and incorporating the students' linguistic and cultural experiences [6,7].

In this study, an equitable pedagogy centers on an opportunity to learn (OTL) science: regardless of a student's race, ethnicity, sex, socioeconomic status, or language proficiency, he or she has access to rigorous content (*i.e.*, cognitively complex and resembles the practices scientists engage in), as well as appropriate supports necessary to learn science and demonstrate understanding of scientific content and practices [8,9]. Classroom assessment allows teachers to uncover whether inequitable conditions exist (*i.e.*, achievement gaps between groups), making it a critical teaching practice. Furthermore, the burgeoning research on formative assessment supports classroom assessment's role in supporting student learning by mediating communication between teacher and students regarding learning progress and what is important to learn [10,11]. When teachers assess LMs in ways that address their lived experiences and diverse modes of thinking and communicating, classroom assessment not only supports learning, but also promotes an equitable pedagogy by increasing *opportunities* for LMs to demonstrate what they know and can do, and, coupled with effective formative assessment practices, by increasing their opportunity to learn rigorous science. Unfortunately, pre-service teachers traditionally lack preparation to assess in ways that aim to support, instead of just evaluate, student learning [12,13].

Deficit views about LMs, in addition to limited knowledge about teaching LMs and assessing student learning, make it particularly challenging for new science teachers to assess in a linguistically diverse classroom. Can pre-service science teachers, exposed to principles around assessing in linguistically diverse classrooms, develop expertise at classroom assessment and apply this expertise during student teaching? What challenges remain? This study's goal was to use a single case study as part of a larger research project to examine these issues and provide insight to guide future studies with different populations of pre-service and in-service science teachers.

2. Theoretical Lens: Integrating Science and Language in Classroom Assessment

A sociocultural perspective sheds light on the relationship between classroom assessment and an opportunity to learn science, drawing heavily on Vygotsky's (1986) notion of the zone of proximal developments (zpd), or the region between what the students can do on his or her own and what he or she can do with a more capable peer [14]. Through assessment, teachers can activate students' prior knowledge and recognize the diverse and legitimate ways in which students reason about the world around them [15]. Teachers can then facilitate learning through purposeful scaffolding toward complex learning goals. Assessment becomes a social interaction driven by big ideas and problems, not a standardized instrument [16]. Reflecting a concern for learning and learner needs, rather than a concern for completing the curriculum or a list of standards [17], assessment serves a formative function–communicating to the teacher and students about learning progress and facilitating learning opportunities [10].

A sociocultural approach also drives theories regarding the role of culture and language while teaching science to LMs. LMs bring diverse epistemologies, lived experiences, and cultures (including languages and second language proficiencies) to the classroom that shape how they view, learn, and communicate their understanding of science [18]. Furthermore, LMs' epistemologies, lived experiences, and cultures influence how they and others perceive their ability to do science–shaping how teachers assess science. For one, science learning, including learning through inquiry, is often incongruent with diverse students' ways of knowing and cultural norms [19].

Language serves particular functions in learning disciplinary content [20–22], which includes a unique lexicon, discourse patterns, and forms of communication. Language allows students to participate in classroom activity; thereby accessing the rigorous subject matter valued by the community [23,24]. To understand core ideas in science, students must learn about how scientific knowledge is constructed, represented, and shared through discipline specific discourses [22–25]. This may happen by engaging students in scientific and engineering practices, such as constructing and critiquing scientific arguments, as well as designing engineering solutions. These discourse forms promote conceptual understanding, investigative competence, and understanding the epistemology and social nature of science [26]. However, a potential challenge for all students, particularly LMs, is that each scientific and engineering practice exposes them to a unique set of analytic and language demands, which must be navigated to learn and demonstrate learning in science [27].

Engagement in the discourses of science not only promotes science learning, but also facilitates second language and literacy development. All students, but again particularly LMs, need practice in using general academic words (e.g., analyze) and language structures commonly used in science in addition to technical science vocabulary [28]. It is insufficient to just have LMs write more frequently in science or use informational texts in science class. Rather, LMs need to be *scaffolded* in their use of language with targeted supports (e.g., modeling instruction, reading and writing strategies, graphic organizers) so they can develop literacy practices necessary for understanding and communicating scientific evidence and core ideas [29,30].

Since language is a cultural tool that mediates learning [31], scholars have argued for the seamless integration of language and science, especially for teaching LMs [32,33], which has been shown to improve science learning for LMs and non-LMs [34]. Science-language integration has informed

research in science curriculum and instruction, but rarely science assessment. However, given how assessment can be embedded into instruction and is a vital activity to support science learning, it follows that integrating science-language while assessing not only would support learning, but also promote an equitable pedagogy for LMs by addressing their particular learning needs and, in turn, increasing opportunities to learn science. For example, in science performance assessments, where teachers observe student performance or observe an authentic student product (e.g., a lab report), LMs have been found to use the language of science productively while they demonstrate inquiry abilities [35]. Assessment also has the potential to enhance student thinking and language use through quality feedback and informed decision making about science instruction.

3. Conceptualizing "Assessment Expertise" in Support of an Equitable Pedagogy

The larger research study investigated pre-service secondary science teachers' assessment expertise over several time points during their teacher education program. Drawing on expertise research [36] and literature on science education, assessment, and teaching content to LMs, three dimensions of expertise were conceptualized: (1) *Assessment Design*–How teachers designed assessment activities (what was assessed? alignment with learning objectives and evaluative/guiding criteria), (2) *Assessment Use*–How teachers used assessment to support learning (purpose/placement in instruction; how was feedback given and how was assessment information used to adapt instruction?), and (3) *Assessment Equity*–How teachers addressed issues of language and culture while assessing to increase access for LMs to rigorous science (and language) learning. The three dimensions were translated into a 4-level rubric (limited expertise, introducing, implementing, and elaborating) that guided both quantitative and qualitative analysis. This study primarily focuses on the Assessment Equity dimension (although all three are interrelated), summarized in Table 1 and described below.

Table 1. Equity dimension of the assessment expertise rubric.

Limited	Introduction	Implementing	Elaborating
Equity: *Fairness*			
Does not consider the fairness (bias) of assessment for LMs	Considers the fairness (bias) of assessment for ELs, such as that (a) students come in with various backgrounds, (b) language /culture influence assessment performance, (c) multiple forms of assessment should be used, or (d) assessment features (content, structure) should be match to the context of instruction	Considers at least 1 strategy that ***draws attention*** to the influence of language and culture on assessments (e.g., modify language, scaffold language, modeling, differentiate assessments)	Considers at least 1 strategy for ***incorporating*** students' language/culture in the design/use of assessment

Table 1. *Cont.*

Limited	Introduction	Implementing	Elaborating
Equity: *Access*			
Does not consider opportunities for LMs to engage in complex thinking, develop language, or fully participate	Considers assessments that allows students to talk science, read or write authentic science texts, or learn the language of science but does not explicitly link this to a need for LMs	Considers (explicitly) how assessment can help LMs fully participate in science, promote complex thinking, or develop language	Considers (explicitly) how assessment can help LMs fully participate in science, promote complex thinking, or develop language **AND** how to provide feedback tailored to LM needs

A teacher demonstrating limited expertise in the Equity dimension would not consider how language or culture may disadvantage (or bias) LMs while assessing. Furthermore, the teacher would be unaware of how LMs are often denied opportunities to productively use language in science and in turn develop academic language and literacy while learning science. From a psychometric perspective, language is viewed as a construct interfering with the interpretation of content knowledge [37–39], and a teacher at the introducing level of expertise would consider, generally, using multiple forms of assessment, modifying assessment to account for the role of language and culture, and inclusion of literacy practices to reduce the demands of language. At the implementing level, the teacher considers specific strategies for supporting students' use of language (e.g., modeling the assessment tasks, discussing expectations, graphic organizers, *etc*.). By scaffolding, instead of merely reducing, language in assessment, teachers can better address sociocultural influences by drawing on language as a resource instead of a factor that needs to be controlled [40] and view equity as more than a technical issue in which bias is systematically removed [41]. Finally, at the elaborating level, teachers can effectively draw on students' cultural resources, including language, as a bridge to learning rigorous science by situating assessment within culturally, linguistically, and cognitively meaningful contexts [15,42,43].

4. Study Context

This study occurred with teachers completing a 12-month long post-baccalaureate teacher education program in a university located in California (western United States). The 12-month long program leads to a single subject teaching credential, a Masters of Arts in Education, and a certificate to provide instruction for English Language Development (ELD) and Specially Designed Academic Instruction Delivered in English (SDAIE). Evident from its mission statement, program courses, and faculty research, the program promotes responsive and socially just pedagogy–particularly for cultural and linguistic minority students.

Pre-service teachers are divided into cohorts—either multiple subject (grades K-6), secondary English, secondary social studies, secondary math, or secondary science. As part of the larger research program, I invited and received informed consent from the entire secondary science cohort (N = 11) to participate in a study investigating their growth in assessment expertise using surveys, interviews,

program artifacts, and classroom observation [44]. Throughout the year, secondary pre-service teachers take core courses in learning, teaching, and language acquisition theory (all focused on teaching culturally and linguistically diverse students), discipline specific theory and method courses, and a quarterly seminar course led by teacher supervisors who observe pre-service teachers in their teaching practicum. Secondary pre-service teachers complete two teaching practicums at two different school sites during the year. All teachers are placed in schools that house a culturally, socially, and linguistically diverse student population—the most common non-English native language being Spanish.

For the study, the secondary science cohorts participated in activities via three courses (*Teaching and Learning in a Diverse Society*—Summer 2010; *Science Education Theory*—Fall 2010; *Science Methods*—Winter 2011) that focused on assessing science in linguistically diverse classrooms. Activities included article discussions, workshops to construct and analyze assessments for their teaching practicum, and case studies–in which the teachers analyzed particular assessment scenarios (e.g., video clips of a science performance assessment) and discussed ways in which assessment constrained or afforded learning opportunities for LMs. All activities were facilitated by the author. Although such ethnographic data was not an expressed goal of the study, observation of and conversations with teachers during instruction naturally helped me interpret their thoughts, struggles, and successes.

5. Method

5.1. Research Design

The larger research project employed a triangulated mixed methods design to analyze quantitative changes in the teachers' assessment expertise (through survey scales and scored responses to open-ended survey prompts and program artifacts), which were then triangulated with qualitative analyses of interviews, classroom observation, and program artifacts [47]. The quantitative and qualitative findings led to a multiple case-study exploration of one particular theme–the developing expertise of addressing language issues while assessing science [48]. These case studies moved beyond general patterns of change from the larger research plan to depict three teachers representing a range of expertise while "retain[ing] the holistic and meaningful characteristics of real-life events" [49]. This paper utilizes a *single* case study, rather than multiple case study, design to present an "extreme" case from the sample [49]. This single case study best highlights the possibilities, and remaining challenges, of preparing science teachers to assess in the service of promoting an equitable pedagogy for LMs.

5.2. Case Study Selection

Described earlier, all 11 teachers completed a common survey at the onset, middle, and toward the end of the program. One open-ended prompt of the survey asked teachers to write out a plan for assessing science throughout a particular science unit. Responses were scored independently by two of three trained scorers, using the Assessment Expertise Rubric (Equity dimension summarized in Table 1), followed by discussion to reach scoring consensus. The scores (ranging from 2–8 in each dimension) reflect teacher capacity to plan assessment as analyzed through multiple conceptual dimensions (Assessment Design, Assessment Use, Assessment Equity). Table 2 displays teacher

scores for two dimensions, Use and Equity, across the three time points. Compared to the ten other teachers, Dean demonstrated the most growth (5 points, from 3 to 8, average growth of sample = 2.55) in how he planned to embed assessment into the curricular context and use assessment to support student learning (Use dimension). In the Equity dimension—representing how teachers' addressed the influence of language and culture, and promoted literacy while assessing science—only 6 of the 11 teachers made any growth (5 teachers improve by 1 point, while Yvonne improved by 2). Dean scored a 5 (out of 8) on the Equity dimension on all iterations of his assessment plan. Although he demonstrating no growth on his assessment plan, his score of 5 consistently ranked as the highest of the 11 teachers. Thus, for this one data source, Dean was extreme in two ways—demonstrating the most growth in the Use dimension (and highest Use score in the May 2011 iteration) and the highest Equity score in all three iterations. Using assessment in ways that support learning may increase opportunities to learn and promote an equitable pedagogy. Aside from being an extreme case within the sample, the contrast of growth between both dimensions allow for exploration of a theoretical proposition: *if a pre-service science teacher evolves in his/her capacity to use assessment to support an equitable pedagogy, then he/she can translate that capacity into classroom practice during student teaching*. Specifically, two research questions are addressed:

1. How does the role of language figure into the teacher's expertise at assessing science throughout the course of his teacher education program?

2. How does the teacher address language while assessing science during a culminating teaching practicum event?

Table 2. Assessment plan scores across the *Use* and *Equity* dimensions (possible range from 2–8).

	Use Dimension			**Equity Dimension**		
	July 2010	December 2010	May 2011	July 2010	December 2010	May 2011
Darlene	2	5	4	2	3	3
Dean	3	7	8	5	5	5
Glenda	2	3	6	3	3	4
Hallie	2	5	5	3	4	3
Lauren	2	6	6	2	2	3
Matt	5	6	7	4	3	3
Michael	4	4	6	5	3	4
Teresa	3	2	4	3	3	4
Whitney	5	5	4	5	3	4
Willow	2	2	6	2	4	3
Yvonne	2	NA [a]	4	2	NA [a]	4

[a] Second iteration of the survey not completed by Yvonne.

5.3. Case Study Data Sources and Collection

Data sources used for the case study include semi-structured interviews, two open response survey items (assessment plan and assessment critique), teacher education program artifacts, observed practice, and a videotaped segment of one particular assessment episode (see Table 3). Semi-structured

interviews, occurring at the onset, middle, and toward the end of the program, averaged 55 minutes and consisted of questions that gauged Dean's beliefs and knowledge toward assessment (e.g., "what does it mean to you to equitably assess student learning?" "how would you assess if you had English learners in your class?" (see Appendix). The survey, given at the same time points, included two open-ended prompts. The first prompt focused on assessment planning, while the second focused on assessment critiquing by presenting a vignette about how "Ms. Sanchez" assessed her students during a particular set of lessons (see Table 4 for details).

Table 3. Data sources across the year.

Beginning of the program (July 2010)	During the program (August 2010 to April 2011)	Toward the end of the program (May 2011)	Notes
Interview 1	Interview 2	Interview 3	Semi-structured with question probes (see Appendix)
Assessment plan and critique 1	Assessment plan and critique 2	Assessment plan and critique 3	Written responses to two open-ended prompts (see Table 4)
	Teacher products	Teacher products	See Table 4
		PACT observations	Audiotaped. Included written field notes and self-reported reflection during interview 3

Table 4. Written teacher products.

Teacher Product (when collected)	Description
Survey assessment plan	Choose one of the following science topics–Mendelian genetics, acids and bases, light and optics, or earthquakes, "describe in as much detail as possible how you would assess student learning during this unit," and "explain why you would assess this way."
Survey assessment critique	Describe and explain to what extent Ms. Sanchez's assessment practices were effective, describe what they would do differently, and list other information (if any) they would like to have about the scenario to comment on her assessment practices.
Teaching and Learning in a Diverse Society final project (August 2010)	Describe three activities to teach a particular science standard and two assessments to assess the learning objectives. Identify (a) relevant learning theories; (b) language demands; and (c) responsiveness for diverse learners.
Science Education Theory assessment case studies (October–December 2010)	Based upon the assessment scenario you observed/participated in and discussed, what modifications would you make (if any) to the assessment and how the information from the assessment is used? How would these modifications support learning and promote equitable assessment for LMs?

Table 4. *Cont.*

Teacher Product (when collected)	Description
Science Education Theory equity essay (November 2010)	Using specific examples from class discussions and readings to date, address the following issues: 1) What do you see as the major equity/diversity themes in science education? 2) What does it mean to contextualize science instruction and what is the rationale/purpose for contextualization? 3) What does it mean to equitably assess students in science and what is the rationale/purpose for this?
Science Education Theory final project (December 2010)	Based on your research into the central concepts, facts, procedures, beliefs, and connections for this topic, describe one appropriate strategy for assessing your topic. Specially discuss: 1) What theories of learning does the assessment task connect to? 2) How will you interpret what students know and can do? 3) How can the assessment be used to support learning and other goals associated with that topic? 4) How will you address issues of equity, particularly for English learners?
Performance Assessment for California Teachers (May 2011)	Task 1: Context for learning Task 2: Planning instruction and assessment Task 3: Instructing students and supporting learning Task 4: Assessing student learning Task 5: Reflecting on teaching and learning

Electronic copies of two course assignments were also collected to provide a more ecologically valid context (demonstrating expertise in the context of actual coursework). The *Teaching and Learning in a Diverse Society* final project (August 2010) reflected expertise at planning assessment (while considering diverse learners) and the *Science Education Theory* equity essay (November 2010) reflected overarching beliefs toward equity (including its relation to assessment).

Toward the end of the program, teachers completed the Performance Assessment for California Teachers, or PACT: a culminating teaching event used to determine whether they had demonstrated proficient competencies associated with the California teaching standards. To complete the PACT, teachers planned and implemented approximately a week's worth of lessons, videotaped two self-chosen segments of these lessons, and wrote an extensive commentary (Dean's was 48 single spaced pages). The PACT commentary asked teachers to (a) articulate how they would plan instruction and assessment, (b) analyze student work, (c) reflect on the effectiveness of their teaching, and (d) address the needs of culturally and linguistically diverse students. I observed two of Dean's PACT lessons in person and collected one of his self-chosen videotaped segments (seven minutes in length). Besides collecting Dean's written PACT commentary, during my final interview with him, I asked Dean to reflect on how he assessed science during the PACT.

5.4. Case Study Analysis

I first compiled all interview transcripts, responses to the survey prompts, as well as additional program products for Dean. I then coded data in each data source by locating text that indicated (a) how Dean conceptualized equity and assessment and (b) his beliefs toward and knowledge about language while assessing. Including multiple sources allowed for triangulation of the data. Finally, data from the various time points were compared to each other [50] to establish patterns of growth over time. For instance, while analyzing the survey assessment plans, growth may be indicated by (a) more identifiable strategies (e.g., modifying assessment text and including a sentence frame) or (b) qualitatively more detailed expression of strategies (e.g., providing an example of a sentence frame). Table 5 provides an example of this coding process from another case study teacher.

Table 5. Sample coding process.

Interviewer question: What, in particular, would you do to make assessment fairer or more equitable for English learners [Language Minorities]?	
Raw Data [Bolded = structurally coded as "Equity Dimension"]	1st cycle (descriptive) coding
Interview 1	
Well I don't have much experience with it yet but I guess just making sure… **Like if I'm giving a written test [a], like make sure all the vocab that I use is stuff that we covered in class [b] and that there isn't anything new** and then you know I guess if there was that they could raise their hand and I could talk to them about it and make sure that they understand… **You know like restructure the question in a way that make more sense to them [c]. So I guess paying attention to vocab[d] and then also I guess giving them different ways to answer the questions because it might be harder for them to respond in English to a complex science question [d,e]. I can't think of how I would do this right now, but just have different ways for them to answer the question [e].**	[a] Attention to literacy or discourse [b] Opportunity to learn content [c] Language scaffold [d] Recognize influence of language/culture [e] Multiple assessment forms
Interview 3	
So I guess like if depending on the level of English Language proficiency [d]... I would probably lean less on the writing and now that I just mentioned... I really like the writing [a]... I would probably provide some other type of... I was just showing them the picture. Like having them work with partners... Like a bilingual student who can help them flush out their writing or just having like a more interview type assessment [c]... I think that might be kind of high pressure for them with me. **Or somehow providing some other scaffolds so that it gets... Well I haven't really used it too much but I like our like matching exercises where instead of them having too think of all this new language on their own [d], like they have pictures and like simple written descriptions and where they match up together[c].... So they don't have to like you know think of it on their own but where they're showing that they know what's going on and that they can like if giving the resources could put it together [e]..**	[a] Attention to literacy or discourse [b] Opportunity to learn content [c] Language scaffold [d] Recognize influence of language/culture [e] Multiple assessment forms

Table 5. *Cont.*

Interviewer question: What, in particular, would you do to make assessment fairer or more equitable for English learners [Language Minorities]?		
Raw Data [Bolded = structurally coded as "Equity Dimension"]		1st cycle (descriptive) coding
Interview 1	Interview 3	2nd Cycle (longitudinal) coding
"So I guess paying attention to vocab [d]"	**"Depending on the level of English Language proficiency [d]"**	More sophisticated attention to student context (language proficiency)
"it might be harder for them to respond in English to a complex science question [d,e]"	**"I like our like matching exercises where instead of them having too think of all this new language on their own [d]"**	Specific action to address language demand (matching exercise)
		Stable view of language as just a barrier

To analyze assessment practices, I engaged in a similar coding process and compiled a profile that included, among other facets, (a) the specific learning objectives being addressed, (b) description of a focal assessment episode used by Dean to analyze student work, (c) strategies used by Dean to address issues of language in the focal assessment episode. The profile drew on the videotaped focal assessment episode, Dean's PACT commentary, and the final interview. The three data sources served as a way to triangulate data.

Coded data were used to write chronological narratives to describe how Dean viewed assessment at the beginning of the program, his evolving expertise over the span of the program, and how he assessed in practice. I conducted a member check [51] to enhance the trustworthiness and validity of the narrative. Dean did not need me to make any changes. The narrative informed the case study reported next.

6. "Assessment in Discourse": The Case Study of Dean

6.1. Introducing Dean

Dean is a 26 year old White male who completed a B.S. in Physics prior to entering the teacher education program. He tutored undergraduate students in Physics, but reported no classroom teaching experience. Dean is a native English speaker with beginning second language proficiency in French.

Coming into the program, Dean believed that students have various learning styles (e.g., visual, kinesthetic) and that teachers should use multiple assessment forms to acknowledge these varying learning styles. Dean expressed some awareness that language influenced student thinking and performance while being assessed in science:

> 'So I am trying to be as visual as possible [while assessing] so you don't really even need language to understand the problem. So you can do that with a general type of question and "here is a ball at the top of the ramp, what is the velocity at the bottom?" like math problems where you have to work your way through and kind of plug and jug questions but also for

> multiple choice questions, there is a way to explain to do assessment for optics or something and you can draw different pathways for light or something, but circle the correct one. So I think visual type of questions…would be good because you bypass the whole language thing.' (Interview 1)

For Dean, the solution to addressing language issues was to 'be as visual as possible [while assessing] so you [the students] don't really even need language to understand the problem.' Thus, Dean's goal was to 'bypass the whole language thing.' Dean stated that one way to bypass students' use of the English language was for students to respond in their native language if he actually spoke the students' native language proficiently. However, Dean was placed in schools where Spanish was the predominant language of LMs–which he did not speak.

6.2. Dean's Evolving Expertise at Assessing Science

To address the ways in which language figured into Dean's evolving expertise at assessing science, two assertions are described.

Assertion 1: Dean became more knowledgeable of the role of language while assessing science.

As he progressed through the program, Dean better understood that language becomes a barrier for students, particularly LMs, to access science content. Dean continued to believe that teachers should use multiple assessment forms to account for learners' varying strengths and learning styles, but shifted his underlying reason to a desire to address *language demands* (*i.e.*, what students have to do with language) associated with assessment. For instance, he discussed how complex text in rubrics could be challenging for LMs. Dean also discussed strategies that would mitigate potential negative influences of language, such as writing rubrics so that they communicate information more succinctly for students:

> 'I mean the goal is to make language less of an issue…The goal is to…try to understand what they [students] know about content without … docking them for language … I feel like it's more valid assessment is what I am trying to say… of their knowledge of the concept.'

Dean moved beyond a limited understanding of language's role while assessing ('don't need language to understand the problem') to now considering language as a factor interfering with his inferences about student understanding of content while assessing. Yet, he still does not treat productive use of language in science as a meaningful *objective* to assess, instead focusing on content understanding.

On his second and last assessment critiques and plans, Dean attended to language in assessment explicitly. On the last assessment critique, Dean wanted to know the specific English proficiency of the students and suggested that the teacher model the structure of explanations by breaking them into 'claim' and 'evidence' for students. On the second assessment plan, he still asked students to *write* scientific explanations, but also stated that the writing might 'be scaffolded,' so that 'assessment would be limited with regards to grammar & syntax but extensive with respect to students [*sic*] grasp of content.' He also attended to language while assessing on his third assessment by using responses to students' think-pair-shares to 'scaffold content and language,' and have students complete a diagram to

assess in a 'more visual and less language-dependent fashion.' Although Dean uses the term 'scaffolding,' he remains focused on reducing the demands of language in actual assessment activities.

> *Assertion 2: Dean developed a belief in incorporating "discourse" while assessing science.*
>
> 'I think… equitable assessment is kinda more based on progress…in the language domain. So, um, when I write those little questions…they kinda challenge them to take things a step further like the quality of their responses…And so, to equitably assess … I just need to really have a back and forth with the student to make sure that … it's not for lack of…inability to communicate that they aren't getting their ideas across'. (Interview 3)

Dean came to believe in 'letting language and science sort of build on each other because they are kind of one in the same for science.' Toward the end of the program, Dean expressed a more specific account of how to integrate science and language through 'back and forth' discourse with his students. For Dean, arguments and other kinds of academic language were 'a vehicle for….addressing the actual concept.' Dean's specific attention to science discourse possibly connected to his increased emphasis on incorporating multiple forms of assessment: 'I saw so many students unable to put an argument altogether in writing…but then, be perfectly capable of demonstrating knowledge…in conversation.' Overall, Dean had developed a position, coined by him, of 'assessment in discourse,' meaning that he thought that he could best uncover student thinking by engaging them individually in dialogue around the concept of interest. However, although Dean used discourse (a form of language) as a way to find out what students knew and could do, he still was uncertain about whether he should *be assessing* language use in addition to science content:

> 'It's going to be hard to sort of separate, um, assessing the language *versus* assessing the content, and I think it's my job to teach them language, but I guess I'm unclear as to whether I should be grading language improvement on top of content improvement or understanding.'

6.3. Dean's Assessment Practices during an Assessment Episode

Dean completed his teaching practicum at Bay High School [52], a public high school in a city of approximately 60,000 people. Bay's student population is predominately Latino (45.2%) and White-non Hispanic (45.8%). Approximately half of the students have low socioeconomic status, and 12.5% are identified as LMs.

The analyzed assessment episode occurs within a conceptual physics class, described by Dean as lower in academic rigor that the other two physics classes offered at Bay (college-prep and advanced placement physics). All 28 students in the class were 11th graders, and 13 were identified as LMs (ranging from beginning to early advanced English proficiency). Conceptual physics focuses on understanding foundational concepts in physics (e.g., energy conservation; relationship between gravity and acceleration) without using sophisticated mathematics (*i.e.*, algebra and trigonometry). The lessons taught by Dean as part of his PACT focused on the following big idea: *charges exert forces on each other and that those forces are responsible for the way charges move*. Prior to the assessment episode, students investigated electric charges by charging and transferring the charges of materials such as rods and pith balls [53]. The assessment episode involved students working in small groups on a *Electric Charges Poster*, where students were expected to draw a diagram of electric charges and

arrows to show the movement of charges, write an explanation on the poster, and converse with Dean about the poster. I focus on Dean's interaction with one group during a three-minute segment.

First, Dean walks over to the group of five students (4 males, 1 female) that has already drawn a model of the materials (rod and pith ball) from the investigation (see Figure 1). As Dean points his finger around the drawn pith ball, he begins by asking the group: 'So the negatively charged rod touches the pith ball? …How does the pith ball get all of this negative charge?' Students hesitate to answer. Dean questions again, 'So positive charge, and these are the arrows? So it's an attractive force. So where did the electrons go?' prompting one student, Hector [54], to point to the diagram and begin explaining: 'They [electrons] move…' while Karla continues: 'They're [electrons] out there and they go into there.' As Karla explains orally, she also writes down the explanation on the poster. The other group members are writing on their lab worksheet. As they write, Dean asks Manuel 'Did the pith ball always have a positive charge or was it neutral—was it no charge?' After Manuel answer, Dean follows up, 'You have a problem. You have to explain this positive charge [as once again pointing to the diagram].' Karla and Manuel discuss what materials are represented on their diagram. Karla asks Dean, 'Are we right?' and Dean responds with 'You might need to reread the directions to remember what happened.' The video clip ends here.

Assertion 1: Dean translated a theoretical stance toward science-language integration into an assessment activity that could promote an equitable pedagogy.

Figure 1. Students Working on the 'Electric Charges Poster'.

As described in the beginning, an equitable pedagogy is one where students have opportunities to learning science that is authentic and supported. Does Dean promote equitable pedagogy through the assessment episode? In the PACT commentary, language figured prominently into Dean's theoretical stance toward science teaching: 'A belief in the interdependence of language and thinking (Vygotsky, 1986) lies at the core of my instructional design for developing my students' knowledge and abilities in both science and academic language.' As Dean explained, 'Structuring in opportunities for discourse is… beneficial for English language learners [LMs]… to practice their language skills… [and] just practice talking, practice writing.'

In the Electric Charges Poster, students used language in a variety of ways to demonstrate their thinking—as opposed to just independently competing paper-and-pencil tests. Students demonstrated understanding of electric charges by (a) writing an explanation on the poster and by (b) engaging in dialogue with Dean. Dean's dialogue promoted scientific discourse in that he at times modeled explanations and expected students to explain what was happening. Karla utilized both

modalities—orally explaining as she wrote the explanation. Dean also provided multiple scaffolds to help students navigate language and deepen conceptual understanding. At multiple points, Dean pointed to student drawn diagram as a way to visualize the movement of charges—also connecting to the investigation previously performed. His questions in themselves served as a scaffolding tool—never telling students the answer, but getting students to reflect on their own explanation—'Maybe you might need to reread the directs to remember what happened.'

Assertion 2: Dean remained focused on assessing conceptual understanding rather than use of language in science.

From direct observation, it is unclear how Dean interpreted and used gathered student work from the jigsaw poster. However, his PACT commentary and final interview provided some insight. Dean identified evidence-based explanations as one of the national science standards that connected to his lesson; yet his specific learning objectives, recorded on the PACT commentary, focused on conceptual understanding instead of explanations as a language learning objective. To interpret what students knew and could do, Dean used a rubric to interpret student performance on the Electric Charges Poster. The rubric was divided into three dimensions—key elements, explanation, and participation. The *key elements* criterion focused on conceptual understanding, indicated by arrows pointed in the correct direction. The *explanation* criterion focused on how students explained *where* and *why* the charged particles move, drawing on their understanding of force. Finally, the *participation* criterion focused on ensuring all members of the group worked together and that *all* members were able to explain the poster. Thus, his interpretation focused on conceptual and participatory elements, instead of use of language.

While analyzing student work, it became clearer how Dean focused his interpretation on conceptual understanding, recognizing language issues:

Given the explanations that many ELLs [LMs] were able to produce today with a little scaffolding, I feel that a more informal, discursive form of immediate assessment could make this an equitable grading practice for groups insofar as I am able to assess understanding of content. This is not to say that academic language is not something worth assessing, but it should be done on an individual basis and not be reflected in the groups' grade.

Dean understood the importance of assessing students' use of language, but the challenge in his mind was negotiating the social nature of learning that happens through his 'discursive form of immediate assessment' and each student's individual needs regarding progress toward using language in disciplinary learning (academic language).

7. Discussion

Language serves particular functions in learning disciplinary content [22–24]. The discourse of science involves, but not limited to, providing evidence-based explanations and arguments. While important for all students, LMs arguably benefit moreso from opportunities to engage in discursive and literacy tasks so that, through scaffolding and feedback, they can develop English language proficiency while learning science. Yet, it remains unclear to what extent beginning science teachers can develop

the expertise necessary to integrate science and language through classroom assessment and how this development translates to classroom practice.

Several assertions made through analysis of the case study highlight the successful development of Dean's expertise as well as the remaining challenges. Dean grew over the course of the program in that he understood how particular texts (even rubrics) might be challenging for LMs while assessing due to the role of language, which prompted him to consider multiple assessment forms. He also integrated science and language while assessing through discourse with student groups and by assessing both written and oral explanations. It is insufficient to just have LMs write or more frequently in science. To promote an equitable pedagogy, one that increases OTL, LMs use of language also needs to be *scaffolded* with targeted language supports to develop literacy practices and understand core science ideas [29,30]. Dean provided some of these supports through student collaboration and participation, potentially increasing LMs' access to rigorous science content and discourses.

Dean's assessment practices were aligned to his belief in integrating science/language while teaching. Yet, the one area where this science/language integration failed to translate to was interpretation of students' use of language in science (using/identifying evidence, appropriately using science vocabulary, and communicating ideas clearly). Instead, he focused solely on students' conceptual understanding. One possibility could have been for Dean to use a rubric that teases out the conceptual understanding from use of language [55]. To communicate expectations, Dean could have also prompted students to use science vocabulary and evidence learned during the lessons while explaining to Dean.

To summarize, even though Dean was exposed to knowledge associated with using assessment to support an equitable pedagogy, and developed the capacity to use assessment formatively and integrate science-language while teaching, his capacity did not fully apply to his assessment practices.

8. Conclusion

Due to science education reform in the United States and internationally, science teachers and teacher educators alike are faced with new challenges regarding the integration of authentic scientific and literacy practices in science classrooms. Both documents emphasize the productive use of language in authentic subject matter contexts (*i.e.*, reading and writing *in science*) and represent a major shift in the role of language in all areas of instruction. This study drew on the literature around science-language integrate to conceptualize assessment's role in supporting an equitable pedagogy. Classroom assessment has the potential to both uncover whether inequitable conditions exist (*i.e.*, performance gaps, denied OTL) and provide an OTL by mediating communication between teacher and students regarding learning progress and what is important to learn. Yet, it is also important to understand the capacity for beginning science teachers to develop expertise in the new roles of assessment. It is uncertain what factors led to Dean's evolution, but possibilities include the assessment-focused activities in his teacher education coursework, opportunities to practice and reflect on his assessment practices via the PACT, and exposure to culturally and linguistically diverse students through the teaching practicums (or a combination of factors). Regardless of his evolved capacity, Dean still did not fully translate a view of science-language integration into his assessment practices, which underscores the challenges that remain in preparing new science teachers, who may

hold onto their deficit beliefs and not adopt a view of integrating science and language while assessing. It will be necessary to help pre-service teachers connect theory and practice in language acquisition to science learning and assessment [56]. Dean could deepen his expertise by noticing strategies through classroom observation, approximating strategies in teacher education coursework, and receiving feedback on his practices during student teaching. Despite the challenges, progress can be made, prompting future research to investigate conditions that might lead to changed beliefs and practices as well as how those assessment practices support an equitable pedagogy.

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Conflict of Interest

The authors declare no conflict of interest.

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Appendix: Teacher Interview Prompts (without probes)

Teacher Assessment Interview 1 and 3

1. When you hear the word "assessment" what are the first words or phrases that come to mind?
2. Could you please describe your experience being assessed in science classrooms? K-12, undergraduate, or graduate school.
3. Could you please describe any experience you have had learning about educational assessment.
4. How do you think students effectively learn science?
5. What does it mean to equitably teach science?
6. How would you describe to a fellow science teacher what it means to assess student learning?
7. Hypothetically, you are asked to construct an assessment of student learning. What are some things you would consider when constructing it? Why?
8. What would you do with the assessment information you gathered about the students? Why?
9. I'm going to show you the prompt and your response to one of the open-ended survey items you answered last week. *[show prompt and response]* Can you take me through the response again and explain your reasoning for the aspects you thought were effective and ineffective?
10. Finally, what does it mean to you to equitably assess student learning?

Teacher Assessment Interview 2

1. Can you describe your experience so far throughout the teacher education program courses learning about assessment
2. How have your cooperating teachers assessed student learning?

3. Have your cooperating teachers explicitly discussed opinions or strategies about assessing student learning?
4. Can you describe your experiences assessing student learning in your teaching placement?

PACT Reflection–additional part of Teacher Assessment Interview 3

Now, I am going to ask specific questions about the focal PACT assessment–that is, the task you used to analyze student work [show or describe task].

1. Can you please take me through the structure of the assessment, what it assessed, and why you chose it.
2. Do you think that all of your students had a fair chance to show what they knew or could do on the assessment? Why or why not?
3. How did you know whether your students learned the learning objectives being assessed?
4. Do you think the assessment contributed to student learning about [the learning objective]?