Balancing Clarity and Inquiry: Developing SEP-Driven Learning Intentions to Support Student Sensemaking in Science Education

By

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Abstract

This case study investigates the disconnect between administrative directives for clear, explicit learning intentions (LIs) and the Next Generation Science Standards' (NGSS) vision for inquiry-based, sensemaking science education. Set within Green River High School, the study explores how a group of science teachers developed a method for crafting LIs that support both administrative clarity and NGSS's three-dimensional learning model, which emphasizes the integration of science and engineering practices (SEPs), crosscutting concepts (CCCs), and disciplinary core ideas (DCIs). The NGSS promotes a shift from content-focused instruction to student-centered, phenomenon-based learning that allows students to think and act like scientists, promoting deeper engagement and critical thinking. However, mandates requiring explicit "We are learning" and "I can" statements often reveal core content before the learning experience, compromising students' sensemaking opportunities. Through professional learning and collaborative practices, the Green River High School science team developed SEP-driven LIs that guide inquiry without "giving away" content, aligning better with NGSS practices. This case study documents the challenges and strategies involved in reframing LIs around SEPs, examines the pedagogical and administrative implications, and offers insights into creating LIs that uphold clarity while empowering student agency. The experience at Green River High School suggests that SEP-driven LIs can support student engagement, critical thinking, and deeper understanding.

Keywords: Next Generation Science Standards, Learning Intentions, Teacher Clarity, Student Sensemaking, Phenomenon-Based Learning, Inquiry-Based Learning, Three-Dimensional Learning

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Chapter 1: Introduction

The journey that led to this case study began with a directive from our district administration at Green River High School. Like many teachers, our team experienced the push and pull between administrative expectations and the realities of the classroom. The directive was clear: Write learning intentions (LIs) in a specific format: “We are learning” statements paired with success criteria framed as “I can” statements. This seemingly straightforward task, grounded in a well-intentioned effort to promote student clarity, became a point of contention for our science team.

Our struggle was rooted in our commitment to the vision behind the Next Generation Science Standards (NGSS; National Resource Council [NRC], 2012; NGSS Lead States, 2013). The NGSS encourages students to actively engage in the scientific process through inquiry-based learning, where they can explore real-world phenomena, ask questions, and develop evidence-based explanations. By focusing on sensemaking and critical thinking, the NGSS aims to prepare students not only to understand scientific concepts but also to apply their knowledge and skills in practical, meaningful contexts (NRC, 2012). Since the adoption of NGSS-aligned standards in Wyoming (Wyoming Science Content and Process Standards, 2016), our team’s teaching philosophy has shifted toward a more phenomenon-based, inquiry-driven approach. The emphasis is rooted in the three-dimensional nature of the science standards, where scientific practices, crosscutting concepts, and disciplinary core ideas are intertwined to foster deeper understanding and sensemaking. This approach encourages students to act like scientists, to explore, question, and develop their understanding of scientific phenomena in ways that promote student agency.

However, the administrative mandate to create explicit LIs felt like a step backward. The examples provided to us were explicit to naming the content, which posed a dilemma. How could we write LIs that met administrative requirements for clarity while preserving the sensemaking and exploratory nature that the NGSS promotes? We were wary of writing LIs that would "give away" the learning, depriving students of the opportunity to engage in genuine inquiry.

Through professional learning sessions, team collaboration, and classroom practice, our team began to wrestle with this disconnect. We questioned how we could maintain the vision of the NGSS while satisfying the demand for clear, explicit LIs. As we had become comfortable with the three-dimensional (3D) nature of the NGSS, we realized that our focus for student learning had also shifted. We cared more about the skills students were building, how they were thinking and engaging with scientific practices, rather than merely the content they were absorbing. This realization provoked a fundamental question: Why not frame our LIs around the scientific and engineering practices (SEPs) students are using, rather than the content they are uncovering?

Problem Statement

Science teachers face the challenge of crafting LIs that not only align with administrative mandates for clarity but also align with the NGSS, which emphasize inquiry-based, phenomenon-driven learning. Administrative mandates often frame clarity as explicit statements of intended content outcomes (Fischer et al., 2019), which can inadvertently compromise student agency and opportunities for sensemaking. The NGSS promotes a three-dimensional learning approach, integrating scientific practices, crosscutting concepts, and disciplinary core ideas through phenomenon-based learning that mirrors authentic scientific practices (NGSS Lead

States, 2013). A disconnect emerges between creating LIs that provide clarity and maintaining the inquiry-driven, sensemaking nature of the NGSS.

Research Question

This case study aimed to investigate how science teachers can develop LIs that provide clarity without explicitly revealing content, in order to preserve the exploratory and sensemaking aspects of science education. At Green River High School, the science team faced the challenge of aligning their LIs with both administrative directives for explicit clarity and the inquiry-driven, three-dimensional approach promoted by the NGSS. However, administrative expectations for "We are learning" statements followed by "I can" success criteria created a tension between making learning goals clear and maintaining the open-ended nature of inquiry-based learning.

This paper addresses the following research question: What theoretical approach(es) might support clear learning intentions for students that align with the 3-dimensional and sensemaking nature of the Next Generation Science Standards? Through this case study of seven teachers within the same district, science department, and building, the paper seeks to identify a practical approach that can support other educators facing similar challenges in balancing clarity with student-centered inquiry.

Chapter 2: Literature Review

The NGSS promotes a transformative vision for K-12 science education, seeking to promote students' ability to think like scientists through a focus on phenomenon-based learning, sensemaking, and scientific inquiry. This approach is a departure from traditional teaching methods, prioritizing student engagement with real-world phenomena and promoting science as a dynamic and interactive process. Developed as part of *A Framework for K-12 Science Education* (henceforth referred to as *The Framework*; NRC, 2012), the NGSS integrates three dimensions: Science and Engineering Practices (SEPs), Crosscutting Concepts (CCCs), and Disciplinary Core Ideas (DCIs), establishing an interconnected and holistic understanding of science. This literature review explores the instructional shifts promoted by the NGSS vision and examines how a common instructional tool, LIs, do not align with this vision. It will investigate the role of teacher clarity and LIs within the NGSS context, examining the disconnect between administrative mandates for explicit LIs and the NGSS's focus on sensemaking and inquiry-based science education.

The Three-Dimensional Model: Integrating Disciplinary Core Ideas, Crosscutting Concepts, and Science and Engineering Practices

The Framework (NRC, 2012) outlines an approach to science education that emphasizes the integration SEPs, CCCs, and DCIs to enhance students' understanding of science as an interconnected discipline. By advocating for a 3D learning model, *The Framework* aims to prepare students to think critically and solve complex problems. Together with the NGSS, a significant shift has begun to take hold in the way science is taught in schools, emphasizing a three-dimensional approach. This approach moves beyond rote memorization of scientific facts to focus on students' ability to think and act like scientists, encouraging them to engage in inquiry-based learning, collaborate, and develop solutions to real-world problems (NRC, 2012; NGSS Lead States, 2013). These shifts require moving away from conventional methods focused on correct answers, rote procedures, and the teacher as the sole knowledge holder, toward engaging students as active participants in the construction of knowledge (Miller et al., 2018; Zangori & Pinnow, 2020). By incorporating these three dimensions, the NGSS aims to foster a more holistic understanding of science, wherein students are not merely passive receivers of knowledge but active participants in constructing scientific understanding. Science teachers have begun the shift to a science-as-practice viewpoint, in which the epistemic agency lies with the student, and science is something to do rather than something to memorize (Furtak & Penuel, 2019).

Empowering Students Through Phenomenon-Based Learning

The NGSS emphasizes the importance of promoting student agency through phenomenon-based learning, in which instruction is anchored around real-world events. According to Penuel and Reiser (2018), this approach encourages students to actively engage in scientific practices by investigating phenomena, generating questions, and constructing explanations based on evidence. Unlike traditional direct instruction, where students passively absorb information, phenomenon-based learning empowers students to take ownership of their educational experiences (Berland et al., 2016). These shifts require moving away from conventional methods focused on correct answers, rote procedures, and the teacher as the sole knowledge holder, toward engaging students as active participants in the construction of knowledge (Miller et al., 2018; Zangori & Pinnow, 2020). In this way, the NGSS cultivates student agency, empowering learners to guide their educational journey and make sense of the world through active inquiry.

Promoting Student Sensemaking

Student sensemaking has been shown to be a central component of the vision outlined by *The Framework* and the NGSS (NRC, 2012; NGSS Lead States, 2013). Odden and Russ (2019) define sensemaking as "a dynamic process of building or revising an explanation in order to 'figure something out" (p. 191). This emphasis on sensemaking aligns with the goals of inquiry-based science education, where students engage in the practices of scientists to construct their understanding of the world. Sensemaking, as emphasized by the National Science Teaching Association (NSTA), requires students to engage with phenomena in a way that mirrors the work of scientists and engineers. By engaging students in hands-on investigations where they develop questions and gather evidence, sensemaking shifts the focus from passive learning to active exploration. The NSTA highlights four key attributes of sensemaking: phenomena, SEPs, student ideas, and science ideas (NSTA, n.d.). By interacting with these elements, students actively construct understanding, allowing them to explore the natural world through inquiry and investigation. This process helps students connect their own ideas with established scientific concepts, facilitating deeper learning and fostering critical thinking skills.

This shift toward phenomenon-based learning and student sensemaking marks a significant departure from the more traditional, linear approaches to science instruction. Research has suggested that the linear and unproblematized structure of the steeped-in-tradition scientific method does not mirror the investigative practices of authentic scientists (Windschitl et al., 2008). By engaging students in real-world investigations, NGSS promotes deeper understanding, encouraging students to explore concepts independently and develop critical thinking skills essential for scientific inquiry. As science education moves toward these phenomenon-based and sensemaking strategies, educators are challenged to design learning environments that support the exploration and skill building essential to prepare students for a rapidly changing world.

Learning Intentions in the Classroom

Learning intentions (LIs) are a tool in education, designed to offer clarity and direction for students, teachers, and administrators. According to Fischer et al. (2019), LIs are defined as "a daily statement of what a student is expected to learn in a given lesson" (p. 19). These statements, also referred to as learning objectives, targets, outcomes, or goals, act as guiding benchmarks that help define what students should know, understand, and be able to do by the end of a lesson or unit. LIs serve as a bridge between curriculum standards and classroom instruction, ensuring that both teaching and learning are purposefully aligned toward specific, measurable outcomes. By providing clarity and focus, they create a structured learning environment where all participants understand the goals and expectations of a lesson (Hartley and Davies, 1976).

Well-crafted LIs help students engage in their learning by making clear what they are working toward, which, in turn, increases their agency and sense of ownership over the process (Marzano, 2007). LIs allow teachers to design and deliver instruction that is targeted and intentional, while also providing a basis for formative assessment. By establishing specific and measurable learning goals, educators can ensure that each lesson contributes to long-term understanding and skill development. Administrators also benefit from clear LIs, as they offer a transparent way to evaluate instructional effectiveness and ensure alignment with standards (Little, et al., 2009). Ultimately, the clarity provided by LIs helps maintain a cohesive learning experience, making it easier for all stakeholders to track progress and outcomes (Fischer et al., 2019).

LIs not only outline what students should learn, but also how they will demonstrate their learning (Fischer et al., 2019). This clarity is especially critical in phenomenon-based science instruction, where the open-ended nature of inquiry can make it difficult for students to know exactly what they are expected to achieve. Well-defined LIs provide a scaffold that supports student exploration and sensemaking while ensuring that learning remains focused on key concepts and skills (Penuel et al., 2017).

The Research Behind Learning Intentions

Research on the efficacy of LIs reveal their potential impact on student performance, although the literature is limited due to the interconnectedness between LIs, assessment, and classroom practices. Still, evidence suggests that well-crafted LIs can enhance students' ability to organize their time and efforts effectively (Minbiole, 2016), facilitate self-regulation in their learning processes, and evaluate their progress towards learning goals (Hattie 2012). While further investigation is warranted to understand the full extent of LIs' impact, it is suggested that thoughtfully developed LIs can play a significant role in improving learning outcomes and fostering an inclusive educational environment (Fischer et al., 2019).

Research also indicates that LIs play a crucial role in supporting teachers' instructional practices and improving classroom dynamics. By clearly articulating LIs, educators can provide a roadmap for their lessons, enabling them to maintain focus and coherence throughout the teaching process (Hattie, 2012). According to Hattie "Learning intentions are a vital aspect of effective teaching, as they clarify what students are expected to learn and understand by the end of a lesson" (p. 81).

The Disconnect Between Clarity and Inquiry

The directive for clear, explicit learning intentions conflicts with the sensemaking and inquiry-based nature of science education as envisioned by the NGSS. The NGSS emphasizes student engagement in scientific practices, such as asking questions, developing models, and constructing explanations, to explore phenomena and derive scientific concepts themselves (National Research Council, 2012). In contrast, explicit learning intentions typically focus on predetermined content knowledge, often revealing DCIs, or content, before students have had the opportunity to engage in inquiry or sensemaking. This creates tension between administrative expectations for clarity, where outcomes are articulated in straightforward terms, and the NGSS vision. Explicitly stating content-focused learning intentions can undermine the core principles of sensemaking by removing the opportunity for students to grapple with phenomena and build knowledge through authentic scientific inquiry. This disconnect challenges teachers to balance the need for clear goals with maintaining an inquiry-based learning environment that fosters deeper understanding. This tension between administrative requirements for explicit learning intentions and the NGSS's emphasis on inquiry-driven, student-centered learning frames the core question of this research: What theoretical approach(es) might support clear learning intentions for students that align with the 3-dimensional and sensemaking nature of the Next Generation Science Standards? By exploring this question through a case study, this research seeks to uncover strategies that help educators reconcile the need for clarity with the NGSS's vision of inquiry, thereby enhancing science instruction that both meets administrative expectations and supports authentic student engagement.

Chapter 3: Submitted Manuscript

Chapter 3 contains the article my colleagues and I submitted to The National Science Teaching Association's journal, *Science Scope,* that summarizes the results of this case study**.** To read this article, see citation below:

Allen, M, Mattson, S., Arnold, E., Carroll, R., Freze, M., Inouye, M., Gunshenan, C., Houseal, A. (January/February 2025). SEP-driven learning intentions: Writing learning intentions that promote student sensemaking and three-dimensional learning. Science Scope. https://doi.org/10.1080/08872376.2024.2433782

Chapter 4: Discussion

The disconnect between administrative mandates and classroom realities forms a central theme of this case study, revealing the complexity of navigating educational directives within the framework of current science education. At Green River High School, the science team's struggle to align LIs with the district's required format while maintaining the vision of the NGSS illustrates this challenge. The shift toward NGSS, which emphasizes sensemaking, student-agency, and phenomenon-based learning, contrasts with traditional approaches to writing LIs that prioritize clarity through explicit content-based objectives. This study explored the efforts to balance this tension, focusing on an approach that emphasizes SEPs over content outcomes. By framing LIs around scientific practices rather than specific content, the science team strived to create a classroom environment where students could build knowledge through investigation and conceptual understanding rather than passively learning facts. This chapter reflects on the key findings and explores the implications for future practice, offering insights into how a theoretical approach rooted in SEPs may help answer the research question: What theoretical approach(es) might support clear learning intentions for students that align with the 3-dimensional and sensemaking nature of the Next Generation Science Standards? Through this case study, we examine the effectiveness of SEP-driven LIs to reconcile clarity and inquiry, seeking to support both administrative expectations and the NGSS vision for science education.

Balancing Clarity with Sensemaking

One of the central issues that emerged from this case study was the difficulty in writing LIs that maintained both clarity and the sensemaking nature of the NGSS. The administrative requirement for explicit "We are learning" and "I can" statements aimed at providing clear, measurable learning goals. However, content-explicit LIs can inadvertently limit the inquiry-driven, sensemaking opportunities that align with current best practices in science education.

The challenge faced by the science team was not merely logistical, but also pedagogical. Traditional LIs, often focused on content, are incompatible with the open-ended, student-led investigations emphasized in NGSS. As noted in the literature review, phenomenon-based learning asks students to generate their questions, investigate real-world phenomena, and construct evidence-based explanations (Penuel & Reiser, 2018). In this model, the practices of science learning are as important as the content, and LIs that preemptively “give away” the learning can undercut students’ sensemaking efforts.

Reframing Learning Intentions: A Focus on Practices

A key insight from this case study was the potential for reframing LIs to emphasize the SEPs students engage in, rather than the specific content outcomes. By focusing on the skills and practices students are using to explore phenomena, LIs can align more closely with the NGSS’s three-dimensional model. Research suggests that SEP-driven instruction enhances students' engagement and understanding by focusing on the processes of scientific inquiry (Furtak & Penuel, 2019). Therefore, by aligning learning intentions with the practices students use to explore and make sense of phenomena, rather than solely emphasizing content knowledge, this approach not only maintains clarity, but also preserves the sensemaking central to NGSS by not telling them the science ideas they are to be investigating. This shift maintains the NGSS emphasis on practices while still providing students with a clear sense of what they are expected to know and do.

Implications for School Districts

The findings from this case study have several implications for classroom practice, particularly in terms of professional learning and teacher collaboration. First, professional learning programs should focus on helping teachers navigate the tension between administrative mandates for clarity and the exploratory, student-driven nature of NGSS. The NGSS require teachers to make substantive changes to their teacher practice (Lee et al., 2014). This can be achieved through a process of incremental change over time using purposeful reflection (Windschitl et al., 2008). As this case study demonstrates, teachers require support not only in understanding NGSS but also in translating its principles into practical classroom strategies that satisfy both pedagogical and administrative requirements.

The professional learning team from the University of Wyoming's Science and Mathematics Teaching Center (SMTC) provided crucial support to the Green River High School Science team as they were developing and implementing the strategy of SEP-driven LIs. Initially, the SMTC team guided us in understanding the foundational elements of the NGSS and the principles behind 3-dimensional instruction, helping our team integrate SEPs, CCCs, and DCIs into our teaching approach. Due to the collaborative nature of our relationship, we were able to openly discuss our concerns about the disconnect between traditional LIs and the NGSS framework when our administration first directed us to write LIs. As our familiarity with the NGSS vision grew, the SMTC team's support evolved to focus on practical application, particularly in creating SEP-driven LIs that balanced student-centered inquiry with the clarity required by our administration. They provided insights on aligning LIs to all three NGSS dimensions, ensuring that our LIs were not only standards-based but also structured to foster active student engagement in scientific practices. Through this collaboration, we developed classroom-specific LIs that adhered to NGSS's emphasis on sensemaking and critical thinking, ultimately enabling us to meet both pedagogical and administrative goals. Furthermore, collaboration among teachers is crucial for developing effective LIs that align with NGSS. According to Lave and Wenger's (1991) model, communities of practice (CoPs) foster learning and professional growth through collaborative activities and shared knowledge within a community. In science teaching, CoPs provide situated professional learning, supporting teachers' instructional growth through shared experiences and reflective practices (Townley, 2020). In this case, the Green River High School science team's collaborative struggle around the issue of LI clarity was crucial in identifying the possibility of reframing LIs around SEPs. Teachers need time and space to work together, share ideas, and experiment with different approaches to writing LIs that support current science practices.

The SMTC further supported the Green River High School science team by securing grants to fund sustained professional learning, as well as opportunities to travel to two national conferences. At these conferences, team members presented their approach to SEP-driven LIs, where the concept was enthusiastically received. Numerous science teachers and facilitators shared similar concerns about the disconnect between NGSS-aligned instruction and traditional LIs but had not yet found a method to reconcile it, highlighting the impactful nature of the SEP-driven approach.

Another takeaway from this case study is the importance of administrative support in fostering a teaching environment that aligns with NGSS. Administrators are crucial instructional leaders in education reform, but their knowledge of science, especially of science practices, remains limited. Administrators often consider inquiry or hands-on activities as good science instruction, but they lack an understanding of sensemaking practices. To support holistic change, administrators need targeted training to supervise science instruction that aligns with current reform efforts, even if they do not need the same depth of expertise as science teachers. (McNeill et al., 2018) While the directive for clear LIs was well-intentioned, aiming to promote transparency and measurable outcomes, it inadvertently created barriers to NGSS-aligned instruction. Administrators at Green River High School were receptive to the science team's concerns and expressed willingness to support their efforts in identifying a viable solution. This suggests the importance of promoting conversation between teachers and administrators to develop a shared understanding of what clarity looks like in the context of NGSS.

Limitations and Future Directions

While this case study provides valuable insights into the challenges and a possible solution for writing NGSS-aligned LIs, it is limited by its context within a single high school and district. Further research is needed to explore how different schools and districts are navigating similar challenges, as well as how these issues play out in different grade levels and among science departments of different sizes.

In this work, we did not intend to measure the effectiveness of these shifts on student learning, therefore, more research is needed to investigate the impact of reframing LIs around SEPs on student learning outcomes and agency. While the Green River High School team's experiences suggest that SEP-driven LIs foster a deeper engagement with scientific concepts and enhance students' sensemaking, additional studies are required to quantify these effects across additional educational contexts.

The relationship between LIs and assessment practices also warrants further exploration. As noted in the literature, LIs are often intertwined with formative assessment (Fischer et al., 2019), and any changes in how LIs are written may have implications for how student learning is assessed. Future studies could explore how NGSS-aligned LIs can be integrated with formative assessment practices that support inquiry and sensemaking.

Conclusion

The experience at Green River High School illustrates the complexities science educators face when balancing the demands of clarity with the pedagogical principles of NGSS. This case study highlights the importance of reframing LIs to focus on scientific practices, allowing for both clarity and the preservation of inquiry-driven learning. The science team at Green River High School found that reframing learning intentions around SEPs may offer an effective approach. By focusing on the skills and practices students engage in, rather than explicit content outcomes, SEP-driven learning intentions provide the clarity required by administrators while preserving the exploratory, inquiry-based nature emphasized by the NGSS. This approach not only supports student engagement and sensemaking but also enhances teachers' ability to design lessons that foster deeper, conceptual understanding and support phenomenon-based learning. These findings suggest that with proper support and professional learning, SEP-driven learning intentions could be a viable solution for educators seeking to balance clarity with NGSS's vision for science education.

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