Learning Scenario Analysis:
Theories, Models and Pedagogy in the Context of Project-Based Learning

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Learning Scenario Description

With the encouragement from administration to incorporate PBL (Project-Based Learning) into our teaching practices, I developed a unit of Grade 8 Science under the PBL framework. My approach to PBL and my Optics unit was to focus on student-driven inquiry. This was my students' first experience of full PBL, but they had become accustomed to the inquiry process from their previous science unit. On the front end, the overarching essential question, design challenge and provocative launch drove the students to ask more questions, and from those questions, I worked alongside the students to help them find the answers. Behind the scenes, I had an array of ideas and activities that I could use to support the students in their inquiry. I also had a general timeline and framework to follow to ensure that the intended learning outcomes were met. This unit took approximately 25 Science classes and covered a substantial portion of the curriculum.

Essential Question: What impact can a tiny house make?

Design Challenge: How can a tiny house be designed to be functional lit with only 1 light bulb?

Learning Objectives (BC Science 8 curriculum, 2018):

- Content: properties and behaviour of light
- Competencies:
  - Identify a question to answer or a problem to solve through scientific inquiry
  - Make predictions about the findings of their inquiry
  - Formulate alternative "If...then…" hypotheses based on their questions
  - Collaboratively plan a range of investigation types, including fieldwork and experiment to answer their questions or solve problems they have identified
  - Observe, measure and record data (qualitative and quantitative) using equipment, including digital technologies, with accuracy appropriate to the task
  - Use scientific understandings to identify relationships and draw conclusions
  - Reflect on their investigation methods, including the adequacy of controls on variables and the quality of the data collected
  - Identify possible sources of error and suggest improvements to their investigation methods

- Construct and use a range of methods to represent patterns or relationships in data, including tables, graphs, key, scale models and digital technologies as appropriate
- Cooperatively design projects
- Transfer and apply learning to new situations
- Generate and introduce new or refined ideas when problem solving
- Communicate ideas, findings, and solutions to problems, using scientific language, representations, and digital technologies as appropropriate
- Consider social, ethical and environmental implications of the findings from their own and others' investigations
- Contribute to care for self, others, community and world through personal or collaborative approaches

Learning Activities and Assessments:

- Launch: Converted classroom into actual sized tiny house lit with only one light bulb. Introduce design problem. Ideate.
- Research: Explore function and impact of tiny homes (social, economical, environmental)
- KWHLAQ Chart on behaviour of light (formative assessment and student reflection)
- Explore properties of light with lab tools and different materials like mirrors and lenses
- Create Your Own Optics Lab (summative assessment) and roundtable discussion
- Drawing light diagrams and floor plans to scale
- Ask an expert
- 2D Tiny House Plan (summative assessment)
- Gallery walk with peer feedback
- 3D Tiny House Plan and showcase (summative assessment)

Learning Scenario Analysis

The main theory this tiny house learning scenario uses is social constructivism. Schrader describes this as the "process whereby learning occurs through problem-solving experiences. For sociocultural constructivists, this activity is shared with another or others, usually more expert, and involves language and collaborative dialogue. Through such guided learning, the process of knowing takes place" (2015, p.25). In brief, this can also serve as a description of PBL, in which the project or problem serves to provide the purpose and real-world context for learning. In my Optics unit, the essential question and design challenge established the parameters for students to explore in and provided the answer to the common "why are we learning this?" question. In social constructivism, situating the learning is important because "the more directly and interactively learners experience phenomena in a meaningful context, the more meaning they are likely to construct" (Ramorola, 2013, p.586).

The PBL framework also relies heavily on student collaboration and teacher coaching. The learning opportunities I designed were very collaborative in nature and placed me, as the teacher, on the sidelines instead of the stage. For example, instead of providing lectures or a dictated step-by-step lab for students, we spent time first exploring different materials and tools that manipulated light. Working in partners, students came up with different ways to "play" with light and recorded their observations. I facilitated this activity by circulating the room, sometimes helping with the use of tools, sometimes offering suggestions, sometimes asking questions to encourage deeper thought, and sometimes celebrating the "cool" discoveries students made. From these observations, students created their own lab, carefully following the scientific method framework, to further investigate one aspect of light. This is a good example of knowledge construction and active learning, two principles of constructivist learning, where it is the students' interactions and experiences *with* light that create understanding *of* light (Ramorola, 2013). Furthermore, students shared their lab results and knowledge of light in a whole class discussion, which allowed them to act as experts and validate each other's findings, thus constructing knowledge together. Students then summarized their work on a shared, online document for all classmates to reference when designing their tiny house. The social interactiveness of this learning experience aligns with another tenant of constructivist learning, where knowledge construction occurs with “social interaction and cooperative learning” (Ramorola, 2013, p.568).

I embedded more social learning in the form of a gallery walk activity, where students laid out their tiny house plans and then toured them, providing constructive feedback on the work of their peers. Social cognitive theory plays a role here too in the form of selective modeling (Bandura, 2011). This activity was a great design catalyst for some students because they were able to see other solutions to the same problem. After the gallery walk, students could improve upon their design by taking into account the ideas of their peers. Bandura (2011) notes that as students adopt their peers’ thinking and remix it into their own, then innovation has occurred through modeling.

The gallery walk was also a chance for me to quickly scan all the plans to find learning gaps that I needed to address, either with individual students or as a whole class. In terms of Vygotsky’s Zone of Proximal Development (Schrader, 2015), I wanted to make sure that students’ zones were not so large that they would give up or be off track, and I wanted feedback as to what scaffolding my students needed for their next steps.

My greatest critique of PBL is the amount of work required of the teacher and the expertise a teacher needs. To be able to scaffold my students’ PBL learning process, I needed to be able to predict and be prepared for the multiple paths students might explore to understand the behaviour of light. I also need to keep track of each group’s progress and ZPD, which meant that during most classes, I was conferencing with each student or group to receive and provide feedback. Little time was left to plan other lessons or grade their assessments. This type of teaching is much more exhausting than standing and delivering a lecture. Although social constructivism does not need the teacher to be the only source of knowledge, I find that the teacher needs to be confidently knowledgeable with a flexible mindset in order to accomplish all of this.

The amount of scaffolding my students needed may in part be due to the fact that my students were still young and just entering Piaget's formal operational stage of development, where they are beginning to think abstractly and able to consider different outcomes (Powell & Kalina, 2009). Trying to design a tiny house with only one light bulb can be quite an abstract problem with many elements to consider from imagining the ideal placement of the light bulb and walls, to conceptualizing where the light rays are going and how they are moving through different materials. Some of my students were more adept to think like this, whereas other students relied on their light lab explorations and physical model making to inform their thinking; a sign that they are still in Piaget's concrete operational stage (Powell & Kalina, 2009). My need to facilitate depended on the proficiency of their formal thinking skills. This makes sense considering that "Piaget's cognitive constructivism theory incorporates the importance of understanding what each individual needs to get knowledge and learn at his or her own pace. Observing students and comprehending their level of difficulty is paramount to this process" (Powell & Kalina, 2009, p.243). The affordance of diversified learning that PBL provides is one of the reasons I am an advocate of this approach. In my tiny house unit, students could assimilate and accommodate new experiences at their own pace, and as needed, re-enter the cycle of self-regulation until the mental structures they were building made sense or reached equilibrium (Good & Kromhout, 1978).

Another activity that helped students construct knowledge through self-regulation was the KWHLAQ chart. This modified KWL chart provided students with a system to organize their thoughts and experiences through retrieving former knowledge, formulating inquiries, reflecting on new learning and considering future action (Landis, 2008). This framework helps students make sense of their learning experiences, which is an important element of Piaget's theory of intellectual development (Good & Kromhout, 1978). Its use in my unit allowed multiple opportunities for students to review, record and reflect on their learning progress. It was also a practical way for students to direct their own learning as the chart's prompts them with questions like "what do you want to know?" and "how will you find out?" This form of self-directed learning or "student-empowered learning" is a key component of PBL and constructivism (Landis, 2008, p.10).

Reflection as a part of knowledge construction is not only important to constructivism and cognitivism, but also to the First People's Principles of Learning (FPPL), which can be considered a learning and instructional theory in its own right. According to FPPL, reflection is part of the learning process to "focus on connectedness, on reciprocal relationships, and a sense of place" (FNESC, n.d.). Another FPPL that is supported by the tiny house unit is "Learning ultimately supports the well-being of the self, the family, the community, the land, the spirits, and the ancestors" (FNESC, n.d.). Having my students consider the value of tiny homes in the context of their ecological footprint and potential social and economical impact aligns with this principle. In addition, students mentioned how meaningful reflection was in this unit because it connected so many pieces of learning together. One of the most interesting reflections students made was how this unit had grown them as a learner. Some of them noted that the different learning activities allowed them to develop their thinking skills, particularly their critical and creative thinking. A memorable response was that one student said she originally thought she was not a creative person, but after presenting her tiny house, she said that she was very proud of how creative her solution was and that now, she is more willing to believe that she can be creative. This is an example of the FPPL that describes understanding one's identity is part of the learning process (FNESC, n.d.). This student's belief about herself changed because of this learning experience.

The strength of the PBL approach is its focus on contextualized student-centered learning. When students are the ones that are actively engaged, whether it be experiential, reflective or inquiry-based, then the more learning they can construct. When they are able to connect abstract concepts to their real-world context, then they are able to think holistically, transfer and apply their understandings, and ultimately develop as a learner.

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