PORTLAND METRO STEM PARTNERSHIP

Patterns Approach HS Science Curriculum and Pedagogy
Design Principles

These design principles have intentionally shaped the courses, units, and teacher instructional practices in the Patterns Approach Physics → Chemistry → Biology science sequence curriculum and Next Generation Science professional development courses. Each course curriculum is revised yearly, with the intention of continuous improvement that is based on the experiences of teachers and students in real classrooms. This document is used as a framework to guide those improvements.

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1. Student-Centered Learning: *Student scientists are placed at the center of each course, continually immersed in opportunities to explain phenomena and solve problems.*

- **Three-dimensional learning -** Tasks demand that students use the science and engineering practices, disciplinary core ideas, and crosscutting concepts to explain phenomena and solve problems. The three dimensions are balanced across teaching, learning, and assessment.
- **Leverage student assets -** Students' existing capabilities, capacities, and funds of knowledge are honored and built upon in new contexts.
- **Hands-on, minds-on** - Students are physically and mentally engaged as often as possible.
- **Teacher as facilitator -** Students develop and iterate explanations of phenomena and solutions to problems while engaging in the practices of science and engineering.
- **Cultivation of STEM identity -** Through consistent use of feedback and metacognition, students are encouraged to cultivate a growth mindset in STEM. By building on successful

experiences, observing that “science works!” and using supports when things become challenging, students strengthen their motivational resilience and academic identity.

2. Collaboration: *Student scientists make sense of the world through a systematic, collaborative process.*

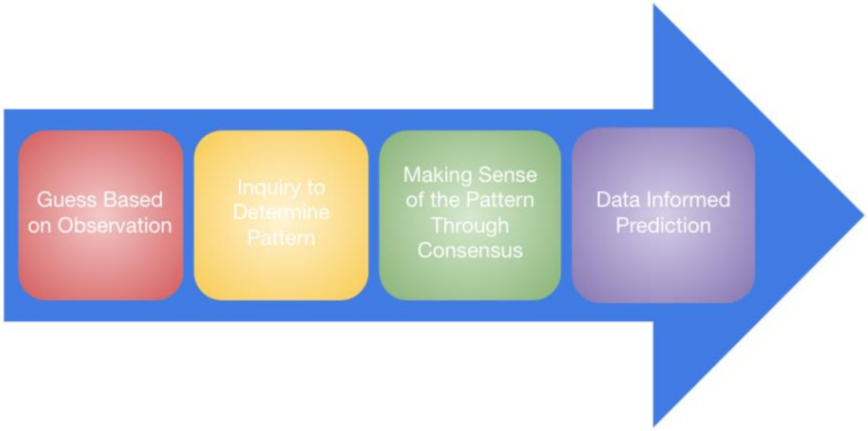
- **Science as a collaborative process** - Science and engineering are consistently framed as collaborative processes. Tasks are designed and assigned in ways that facilitate students working together to co-construct knowledge, in much the same way that real-world scientists and engineers do. For example, different groups might investigate different variables in a system in order to construct an explanation that accounts for the entire system’s behavior.
- **Group accountability -** Group tasks are organized in such a way that each individual has an essential role to play. Roles may vary by task; however, the amount of work to be done should always be proportional to the group size.
- **Class accountability -** Each group is accountable to the whole class to report and share its findings. A complete explanation of the phenomenon at hand depends on each group’s contribution to the whole.
- **Building leadership skills -** Capacity for leadership skills is built by every student as they engage in small and larger group interactions.

3. The Patterns Approach to Inquiry: *Student scientists observe, understand, and use patterns and trends in physical and natural systems in order to predict the future, make data-informed decisions in the present, and understand the past. Inquiry activities are designed to take students through a repeated process of the following steps:*

- **Guess based on observation -** students make a wild guess about the behavior of a phenomenon and hypothesizing about a more generalized explanation of the phenomenon. The purpose of the wild guess is ultimately to contrast it with students’ data-informed predictions, highlighting the value of the scientific process and evidence-based reasoning.
- **Inquiry to determine the pattern -** students follow (or develop) a method for the gathering of data for one of many variations of the research question through a jigsaw approach. The purpose of this approach is to give students a meaningful opportunity to communicate their group’s unique data-set and then analyze the collective evidence as a class, observing one or more of the following:
  - **Mathematical patterns -** e.g. a constant velocity system can be explained through a linear pattern, decay of radioactive material can be explained by a negative exponential pattern, and some characteristics are inherited in predictable ratios.
  - **Trends -** e.g. as the amount of CO_2 in the atmosphere increases so does the energy stored in the Earth system, electronegativity trends across the periodic table, and the carrying capacity of an ecosystem is determined by the dynamic relationships between biotic and abiotic factors.
- **Making sense of the pattern through consensus -** students engage in a data discussion that deeply analyzes the experimental evidence and explains the components of the

mathematical pattern or trend. They can then generate an informed explanation of what was observed.

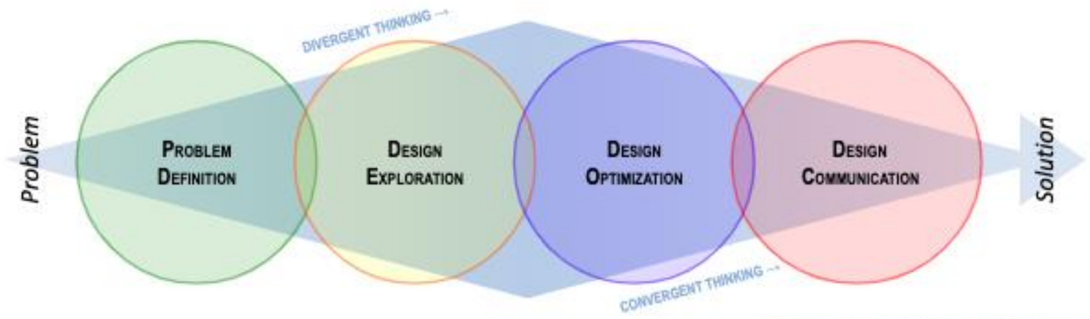
- **Data-informed prediction -** students return to the initial phenomenon, making a new, data-informed decision that utilizes the identified pattern, and compare this new prediction to the actual value, either by research or an additional test. This process makes evidence-based reasoning explicit.



4. The Patterns Approach to Engineering: *Student engineers apply and deepen their knowledge of concepts by investigating problems and designing solutions.*

- **Design Methodologies -** engineering activities are designed using one of the three following methodologies, all of which emphasize students using data and evidence to inform their designs:
  - **Rapid Prototyping -** for solutions that are quickly developed and easily testable, an example of this would be the design of a method to send and receive a binary coded message using light and sound.
  - **Collaborative Data-Informed Design -** if a solution would be time-consuming to make and test, and/or has multiple variables, the jigsaw approach is used for the initial data collection phase, and student groups use the results to design a solution that satisfies the criteria and constraints. (e.g. shoe, wind turbine, candy, algae biofuel, and water quality projects)
  - **Research-Informed Design -** students use information provided as well as their own research to develop a conceptual and/or mathematical framework that guides their design choices. For example, by researching the impact of variables on design function, students can make informed choices to meet their criteria and stay within their constraints. (e.g. Barbie bungee, yogurt, wildlife corridor, and soap projects)
- **Design Process** - regardless of methodology, students engage in the following processes of engineering to develop their solutions:
  - **Defining the Problem** - identify the problem to be solved and the associated criteria, constraints, and tradeoffs.
  - **Developing Possible Solutions** - use data, research, and/or rapidly tested prototypes to inform the design of the solution. At a few points in this process, students share ideas and initial findings, identifying pros and cons in light of trade-offs, finally coming to consensus about which solution to iterate.

- **Evaluating Solutions** - students evaluate the strengths and weaknesses of their final design, including suggestions for improvement based on data from their final constructed design.



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5. Culturally Responsive: *Phenomena and design challenges are selected so that student scientists find relevance in the connection between their identities and lives and what is studied in the classroom.*

- **Caring relationships -** Teachers foster and facilitate a classroom environment where students are included, respected, valued, and cared for. Included in this communication of belonging *generally* is the communication that students belong *in science*. Teachers foster a sense of reciprocal accountability for respect *and* STEM learning.
- **Valuing student capital -** Experiential, cultural, linguistic, and academic assets students bring to the classroom are sought out and connected to lessons, units, and classroom tasks.
- **Relevance -** Anchoring phenomena for each unit, as well as individual lesson phenomena, are chosen based on their relevance to the lives of students and their diverse communities as well as their connections with the NGSS performance expectations.
- **Place-based -** Units and individual lessons make connections to local phenomena and problems, whenever possible. Further, those local phenomena are connected to global issues.
- **Taking action for social and environmental justice -** Students learn about the challenges at the intersections of science and society and are empowered to take action to solve those problems.
- **Career connections -** A variety of careers are highlighted and students are able to connect both the course content and career-readiness skills they develop in their courses to their future goals. Students engage in opportunities to experience science and engineering practices in projects that resemble real-world situations to help them explore and prepare for their post-high school futures.

6. Differentiation: *Every student scientist succeeds on differentiated, rigorous tasks.*

- **Multiple entry points -** Tasks are designed so that students are able to access the content and skills demanded at a range of initial levels of proficiency. Moving from this initial level, tasks guide students to the next level of rigor and complexity with supports and the use of formative assessment and feedback.
- **Challenge -** Tasks utilize the highly proficient category on the rubrics, and courses offer honors options to challenge students to achieve the next level.

- **Developing confidence in *doing* science** - Students arrive with different levels of content knowledge and skills, but by engaging in scientific experiences together, they can come to the realization that the process of science is complex and each individual can contribute to creating a more complete and accurate explanation of the world.

7. Language Rich: *Science content is taught in conjunction with language. Curriculum and instruction emphasize speaking, writing, interacting, reading, and listening, thereby increasing the academic language capacity of all students, and in particular English Language Learners.*

- **Language supports -** Sentence starters are provided for writing and speaking tasks, prioritizing multiple options so as to move away from fill-in-the-blank and towards more sophisticated use of transferable scientific and academic language.
- **Organizational resources -** Concept maps, models, and graphic organizers are used to aid students in transitioning their scientific understanding from rough to developed written or oral explanations.
- **Regular opportunities for facilitated discussion -** Rich discourse occurs frequently, in data discussions, class/group interaction, structured talk protocols, and other discourse opportunities.

8. Three-Dimensional Assessment: *A balanced system of formative and summative assessment, linked to the performance expectations of the NGSS, provide frequent opportunities for teachers to monitor learning, make instructional adjustments, and assess learning. Assessment opportunities are clearly linked to the standards, and rubrics provide feedback, allowing students to track their progress.*

- **Three-Dimensional Assessment -** performance tasks are written in ways that demand students use the practices of science and engineering, with science content and crosscutting concepts embedded in the task, rather than isolated. In other words, students apply content knowledge and crosscutting concepts to develop explanations, models, solutions, questions, etc.
- **Clear objectives/learning targets -** expectations for each task are clearly communicated to students.
- **Formative assessment** - each unit features frequent opportunities for students to gauge their progress and continue to develop their skills and understandings. Students are encouraged to practice in a low-stakes environment (e.g. classroom activities, homework) so as to gain proficiency in preparation for being assessed summatively.
- **Self- and peer assessment** - There are frequent opportunities for self and peer assessment. This places the ownership with learning to the student and encourages metacognition.
- **Rubrics** - tasks are presented with rubrics to enable consistent self, peer, and teacher assessment as well as to clearly communicate expectations.
- **Summative assessment** - Each unit has a variety of summative assessments (e.g. quizzes, projects, tests, labs, engineering projects). This enables the teacher to make a more holistic judgment of student learning across the unit and allows the student to demonstrate their learning in a variety of modes and contexts.