Finding the Common Thread: Learners’ Intuitive Knowledge of General Patterns that Apply Across Domains

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Abstract: This study explores learners’ intuitive knowledge of the general patterns of change that apply across multiple domains. Examples of such patterns are oscillation, equilibration, and threshold. Intuitions of these patterns can be leveraged in the design of constructivist science instruction. Clinical interviews elicit pattern intuitions by showing participants highly schematic simulations designed to illustrate each pattern. Participants are then prompted to generate examples of phenomena that follow each pattern. Preliminary analysis suggests that students have rich intuitive knowledge regarding general patterns that transcend various domains.

Introduction
In this study I explore learners’ intuitive knowledge of the patterns of change that apply across multiple domains. This work is situated within a larger program that aims to design equitable science instruction by building normative understanding of dynamical systems topics on the foundation of students’ intuitive knowledge of patterns. Following a Knowledge in Pieces (KiP) perspective, I view intuitive knowledge as a rich and productive resource for learning that all students bring to the classroom, regardless of prior educational opportunity (diSessa, 1993; Smith, diSessa, & Roschelle, 1993). Intuitive knowledge of patterns, in particular, is powerful for learning because:

1. Patterns can be analyzed in a diversity of engaging contexts belonging to both psychosocial and physical domains.
2. Patterns provide an intuitive framework on which to ground the construction of normative understanding of important topics of both classical and cutting-edge science.
3. Pattern-finding is an inherently scientific activity. By looking for the patterns that transcend seemingly unrelated phenomena, students engage in an important practice of professional science.

Methodological Approach
I explored the intuitive pattern knowledge of three 9th grade students. The students were of ethnic minority and from low SES families, and had been designated by their school’s academic support staff as “at-risk” of failing or dropping out of high school. Participants were intentionally selected from this population in order to gather evidence in support of the claim that all students, regardless of prior educational opportunity, come to school with a knowledge base richly populated with intuitions that are productive for learning. Prior work with high SES participants suggested that students can meaningfully engage in this subject matter and I anticipated finding similar engagement with students of low SES.

Each student participated in a clinical interview that lasted about thirty minutes. During the interview participants were shown highly schematic simulations designed to illustrate each of four patterns relevant to the study of physical systems. These patterns are threshold, hysteresis, critical damping, and linear control. After viewing each simulation, participants were asked to describe the behavior of the elements in the simulation and then generate examples of physical or psychosocial phenomena that followed the same pattern, or respond to interviewer generated examples. For all examples, students were asked to explain mappings between examples and simulations.

Preliminary Analysis 1: Students have Rich Intuitive Knowledge Regarding Patterns
The participants generated a number of examples of both physical and psychosocial phenomena for each pattern simulation (see Figure 1, below). In general, I found that these students engaged well in the tasks and connected phenomena to simulations with relative ease. Broadly speaking, the work of these students seemed to be quite comparable with that of higher SES, academically oriented students.

Figure 1: Total number of student-generated examples of physical and psychosocial phenomena that follow the pattern of each simulation.
Preliminary Analysis 2: Intuitive Knowledge of Patterns Transcend Domains

Analysis of a small portion of an interview with one student, referred to as Anita, is reported below as an illustrative case where the same pattern was recognized in phenomena of both physical and psychosocial domains.

Anita was shown a simulation designed to illustrate threshold. I schematize threshold in relation to a transition between two modes of action. Actions of the initial mode are characterized as approaching a transition. Final mode actions are the result of the transition. The point at which the transition occurs is the threshold. A series of three screenshots is provided in Figure 2 (below) to give the reader a sense of the elements and sequence of events in the threshold simulation. The simulation begins with two elements, a red circle and blue rectangle, at rest (Figure 2, left box). The user moves the blue rectangle horizontally to the left with the mouse until the rectangle reaches the circle and pushes it to the left (Figure 2, middle box). The circle reaches its threshold and reacts by flying leftward away from the rectangle (Figure 2, right box). In this simulation, the initial mode of action is illustrated by the rectangle pushing the circle. The final mode of action is illustrated by the circle flying away from the rectangle. The threshold is a location on the left side of the screen at which the circle transitions from being passively pushed along by the rectangle to actively flying away from it.

![Figure 2: A series of screenshots show three moments in time to illustrate the sequence of events in the threshold simulation.](image)

Although Anita did not use the word threshold, she recognized examples of phenomena from both physical and psychosocial domains that followed the pattern illustrated by the simulation. She indicated a sense of threshold in the physical phenomenon (suggested by the interviewer) of pushing an object up a hill until it crosses the threshold of the peak and as a result, rolls down the hill on its own. As well, she indicated a sense of threshold in the psychosocial phenomenon of breaking a habit of skipping class (an example she generated on her own).

Like if someone is like/ just they could/ say skipping class or something like that/ and you do it like constantly and then you try to break the habit and then after a while you just like/ you've had enough and you just go to class

Her language indicates an intuitive sense of the threshold pattern. In her example, the initial mode of action is illustrated by skipping class “constantly.” The final mode of action is going to class. The threshold is the point at which “you’ve had enough” and a transition is made from the first mode of action to the second - from skipping class to attending it.

Future Work

Preliminary analysis suggests that students have rich intuitive knowledge concerning patterns that cut across physical and psychosocial domains. In order to more thoroughly characterize the nature of students’ intuitive knowledge regarding patterns and the phenomena they underlie, analysis will be conducted of the mappings made by participants between examples of physical and psychosocial phenomena and the simulation. Additional interviews will be conducted with students of non-dominant ethnic groups and low SES and contrasted with data collected from interviews with students of dominant ethnic groups and higher SES to provide statistical evidence in support of claims regarding the universality of these productive intuitive resources.

References
