**INTRODUCTION**

Learners are better able to complete representational transformational challenges with the aid of touch-screen tablet technology than using the traditional means of static ball-and-stick images or physical models. To better understand this quantitative result, qualitative research interviews were conducted to determine how learners use and transform between various chemical representations. This involved moving into the second domain of Hutchings’s Taxonomy of Teaching and Learning Research Questions.

**FRAMEWORK**

Phenomenography is a qualitative research framework that focuses on participant descriptions of a particular phenomenon. This framework assumes that there are a limited number of quantitatively different ways a given phenomenon can be experienced or perceived.

The goal for this study was to identify what strategies learners develop as they solve matching problems for chiral compounds using various chemical representations. Phenomenography was used as the framework to study these problem-solving strategies through the student voice. Data is collected until saturation is achieved to generate the associated outcome space.

**TYPES OF OUTCOME SPACES**

There are three possible types of outcome spaces, based on the structural relationships between the categories of identified experiences.

- an inclusive, hierarchical, outcome space;
- a developmental progression outcome space;
- an interviewee past-experience dependent outcome space.

**RESEARCH QUESTION**

What problem-solving strategies do learners describe as they experience the task of transforming between chemical representations of chiral compounds? (Printed ball-and-stick image, physical model, or manipulable ball-and-stick image in a 3D virtual space versus structural formulæ)

**METHODS**

1. Participant interviews are based on a common protocol with randomization for order of chemical representations ($n = 20$)
2. Thematic analysis is used to identify codes within a subset of transcribed interviews. Initially, open coding is done individually by research team members.
3. Coding system is applied to remaining interviews.
4. Team members compare and iteratively refine codes to reduce individual bias. Codes are collected into emergent themes.

**RESULTS**

This study resulted in a developmental progression outcome space, meaning that categories for how a phenomenon is conceived can be ordered by their explanatory power.

During the exercise of matching a provided representation (printed image, physical model, or virtual 3D image) to a structural formula, the experience of an individual participant was usually not restricted to only one category in the outcome space. Descriptions of the phenomenon revealed the process learners would move through in their problem-solving strategy development.

Three distinct problem-solving strategies were described by participants. When comparing two representations, learners would select one of the coloured atoms (e.g. the green chlorine atom in the representations below) and compare its placement with another atom (e.g. the dark red bromine atom).

**IMPLICATIONS FOR TEACHING**

Learner progression through the three observed problem-solving strategies with any of the technologies was unidirectional, toward the more successful strategies. This supports the use of experiential learning and guided inquiry activities with chemical representations.

Furthermore, development did not necessarily carry over into subsequent phenomena. When solving a chiral matching problem using a new type of chemical representation, participants redeveloped previously identified strategies, even if they were known to be unsuccessful strategies.

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