# Misconceptions and Conceptual Change in Knowledge Building Environments

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**Abstract:** The resistance of students' naive scientific conceptions to ordinary instruction has encouraged the belief that these conceptions are deeply held and that extraordinary measures are required to change them. The present study analyzed Grade 4 students' discourses about optics in order to uncover students' level of consciousness of their naive conceptions, their level of commitment to their misconceptions, and their peers' collective cognitive responsibility to improve those conceptions. The results of this study not only show that students are able to recognize a gap/conflict in their knowledge, but also provide evidence that students willingly seek information to improve their naive conceptions. The study also provides promising evidence that peers may facilitate the process of conceptual change by providing support in various ways.

**Keywords**: Knowledge Building, misconception, conceptual change, collective responsibility

## Introduction

Although contemporary researchers hold a number of different views about students' naive conceptions in science—as shown for instance, in the first five chapters of the *International Handbook of Research on Conceptual Change* (Vosniadou, 2013), there seems to be continuing agreement since the early days of research on this topic (e.g., Driver & Easley, 1978) that many common misconceptions are resistant to change and that changing them requires a skilled and knowledgeable teacher. The implication is that students are satisfied with and perhaps deeply committed to their erroneous conceptions (Mestre, 1991). A more optimistic view of prospects for conceptual change is put forth by contributors to the book, *Intentional Conceptual Change* (Sinatra & Pintrich, 2003), although this appears to be a minority view. If the more pessimistic view is correct, it poses a serious challenge to constructivist approaches that assign a high level of agency to students in their cognitive development. With Computer-Supported Collaborative Learning (CSCL) there is even the risk that misconceptions will spread. Burtis, Chan, Hewitt, Scardamalia, and Bereiter (1993) investigated this possibility with students using CSILE, a predecessor to Knowledge Forum®. Although the authors found numerous misconceptions, most of these were ignored by other students, and of those that did receive comments, more were contradicted than were endorsed. The present study is a pilot study that attempts to go more deeply into the group treatment of misconceptions in a Knowledge Building class—a class previously described by Messina and Reeve (2006). Applying a scheme that categorizes types of contributions to knowledge building dialogue, the study investigated the distribution of misconceptions over different types of contribution and also the types of contributions represented by responses of students to Knowledge Forum notes containing misconceptions. The overarching question guiding the research was whether students recognized problems with their naive conceptions and sought information to solve them. A cardinal principle of Knowledge Building is that students should take collective responsibility for idea improvement (Scardamalia, 2002). To the extent that they actually do this, there should be student-driven progress from naive to more sophisticated conceptions.

## Method

The primary data source in this study was Grade 4 students' discourses about optics, posted in Knowledge Forum®—a web based discourse medium specifically designed to support production and refinement of community knowledge to advance understanding of the world and effective action through social interaction. Knowledge Forum provides an editable set of *epistemological markers* that are called *scaffolds*. Knowledge Forum scaffolds, such as *I need to understand* and *my theory*, can be integrated into students' notes to show their "thinking types" and encourage discourse and metadiscourse (Scardamalia & Bereiter, 2006). This study is focused on *I need to understand* and *My problem of understanding* scaffolds. In this study, first all notes that contained at least one of these two scaffolds were examined in order to identify students' misconceptions. Then, all these misconception notes, as well as peers' responses to them, were analyzed and categorized. The scheme used to categorize students' notes was the ways of contributing framework (Chuy, Resendes, & Scardamalia, 2010), which identifies six major categories of student contributions, along with 24 sub-categories.

## Data analysis and findings

### Identifying and categorizing students' misconceptions

A total of 308 students' notes were reviewed and 38 notes with *I need to understand* or *My problem of understanding* scaffolds were recognized. Among these 38 notes, 16 misconception notes were identified and categorized according to the ways of contributing scheme, taking into account the fact that some notes may fall into more than one category (Chuy et al., 2010). For example, the following note contained the student's personal opinion as well as an explanation question (categories 1 and 23):

> Note 1: {[My problem of understanding]:}Why does light bounce of a mirror with tissue paper on it and without it. Me and Ray think it is because of the mirrors. We could be wrong!

Table 1 shows a summary of the five identified categories and seven identified subcategories (Subcategories numbered according to Chuy et al., 2010's work).

Table 1: Students' types of misconceptions

| **Major Categories** | **%** | **Sub-categories** | **%** |
|---|---|---|---|
| Thought-provoking questions | | 1/Explanation questions ("why"/ "how" something happens) | 22.22 |
| | | 2/Design questions (how something can be proven or tested through experimentation) | 2.78 |
| | 36.11 | 3/Factual questions ("who"/"what"/"where"/"when" questions) | 11.11 |
| Theorizing | 13.89 | 7/Seeking an alternative explanation (looking for different explanations than those that have been posed) | 13.89 |
| Obtaining Information | 13.89 | 8/Asking or looking for evidence to support a particular idea | 13.89 |
| Working with Information | 2.78 | 15/Providing an evidence or reference to support a particular idea | 2.78 |
| Supporting Discussion | 33.33 | 23/Giving an opinion (students' personal opinions) | 33.33 |

As shown in Table 1, students' misconceptions mainly appeared in two subcategories: notes that expressed their personal opinions (33.33%) and notes that asked explanation questions (22.22%).

### Examples of students' misconceptions

The existing literature demonstrates that students may not realize that we see objects because light reflects off all objects (including non-luminous/non-glossy objects) to our eyes (Anderson & Smith, 1986); rather, they usually consider light as something that is necessary to see objects, as it *illuminates* the environment (Watts, 1984; Shapiro, 1989). In this study, Grade 4 students' discourses about light were analyzed and a number of notes indicating misconceptions about vision were identified. For example, the authors of Note 2 perceived that tissue paper cannot reflect the light; rather, the mirror is the reason for reflection:

> Note 2: {[My problem of understanding]:}Why does light bounce of a mirror with tissue paper on it and without it. Me and Ray think it is because of the mirrors. We could be wrong!

In fact, they do not realize that if tissue paper does not reflect light, the eyes cannot see it. Another note (Note 3) shows that its author thought light is necessary to *illuminate* the environment and eliminate darkness, and did not know we need light to be reflected from the objects toward our eyes:

> Note 3: {[My theory]:}{[I need to understand]:}if we can see without light. I read a reading that said you can only see with light. : I agree. I do not think that your eyes can adjust to the dark and see because you need light to see.

Not only do we need light to see objects, but the color of objects also originates in light; however, some students see no relation between color and light (Galili & Lavrik, 1998; Guesne, 1985). Moreover, many students may think only one color comes out of a flashlight (Haslag & Concannon, 2012). Our analysis also confirms the existence of misconceptions about color. For example, Note 4 confirms that students may not be able to identify the relation between light and color (e.g. rainbow). Also, Note 5 shows that students may think only one color (white) comes out of the classroom bulb:

> Note 4: {[I need to understand]:}What does a rainbow have to do with light?
>
> Note 5: {[I need to understand]:}what you mean by "green" light? In our classroom the light is white.

As these examples indicate, children in this study exhibited the kinds of misconceptions commonly observed in other research. However, in all the misconception notes analyzed in this study, students judged their ideas and knowledge, and were able to recognize a gap in their knowledge and theories. Therefore, they did not state their naive ideas with confidence; rather, they used *I need to understand* or *My problem of understanding* scaffolds to express their doubts or problems of understanding, and to request their friends to criticize and improve their ideas.

### Peer response to misconception notes

Classmates' responses to misconception notes were analyzed according to the ways of contributing scheme, and categorized into six categories and 13 sub-categories (Table 2).

Table 2: Ways of contributions of responses

| **Major Categories** | **%** | **Sub-categories** | **%** |
|---|---|---|---|
| Thought-provoking questions | 2.44 | 1/Explanation questions | 2.44 |
| | | 4/Proposing an explanation (propose ideas to explain phenomena) | 14.63 |
| | | 5/Supporting an explanation (by providing reasons or justifications) | 4.88 |
| | | 6/Improving an explanation (by elaborating/identifying new details or applying new evidence) | 17.07 |
| Theorizing | 39.02 | 7/Seeking an alternative explanation than those that have been posed | 2.44 |
| | | 8/Asking or looking for evidence to support a particular idea | 2.44 |
| Obtaining Information | 4.88 | 12/Introducing new information from experience | 2.44 |
| | | 15/Providing an evidence or reference to support a particular idea | 4.88 |
| | | 16/Providing an evidence or reference to contradict a particular idea | 12.20 |
| Working with Information | 26.83 | 18/Accounting for conflicting explanations (providing information or evidence) | 9.76 |
| Synthesizing and Comparing | 9.76 | 20/Using an analogy (to attempt to explain or describe something) | 9.76 |
| | | 23/Giving an opinion (students' personal opinions) | 9.76 |
| Supporting Discussion | 17.10 | 24/Acting as a mediator (negotiations with other students) | 7.32 |

As indicated in Table 2, peers mainly tried to help solve conceptual problems by elaborating new details/applying new evidence to improve explanations, or by proposing new ideas to explain phenomena. They also tried to make their friends aware of their misconceptions, using analogies or providing evidence/references to contradict a particular idea or account for conflicting explanations. For example, in response to a student's misconception regarding the eyes capability to adapt to light levels and, as a result, vision without light (in a completely dark room) one student wrote:

> Note 6: {[My theory]:}I was shut in a small clost for 15 minuts and my cousin was in it to. after 15 minuts we still could not see anything. Sois that your eyes will not be able to ajust to a picth black room. we where playing hide and seek.

## Discussion and conclusions

Overall, the findings of this case study support and add a social dimension to the idea of intentional conceptual change. The study showed that students as young as age 10 have some recognition of problems with their naive conceptions and willingly seek information/criticisms to resolve those problems. A further educationally significant finding is the willingness of students to take collective cognitive responsibility to improve the knowledge of the community and solve their peers' misconceptions. While 33.33% of students' misconception notes contained their personal opinions, only 9.76% of responses were personal opinions. Instead, the most frequent contribution types of responses were theorizing (39.02%) and working with information (26.83%) in which peers tried to improve the existing explanations (17.07%), propose new explanations (14.63%), provide evidence or reference to contradict (12.19%) or account for conflicts (9.76%). They also used analogies (9.76%) to make the situation clearer and help their peers understand the phenomena.

When expressing their naive theories and ideas, Grade 4 students used *I need to understand* or *My problem of understanding* scaffolds to show their uncertainty about their ideas and theories. To use these scaffolds, students need to judge their knowledge and recognize a conflict or gap in their understanding. Indeed, the very use of these scaffolds suggests that students are not committed to their misconceptions); rather, they willingly encourage their peers to respond to their questions/misconceptions in order to improve their ideas. Although these results do not show actual conceptual change taking place—movement from a naive to a more sophisticated conception—they show the antecedents of conceptual change one would expect to find in mature scientific thinkers: dissatisfaction with the current state of understanding and ability to translate this dissatisfaction into potentially solvable problems.

## Future work

The preliminary results of this study provided evidence that the required steps of conceptual change can be taken in a student driven environment. However, this study lacks the evidence to show students' ideas improved and misconceptions solved. In the next step, we will replicate the study with more datasets, focusing on tracing the misconceptions to examine if and how ideas evolve and conceptual change takes place in student-driven environments, without teacher interventions.

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