

Examining the Physical Science Misconceptions of Middle Primary Students

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Abstract: With technological advances impacting future work prospects, and issues such as climate change and environmental protection affecting our lives and resources, it is imperative to improve the scientific literacy of children, and thus future adults. There is a large body of research into the common misconceptions held by children about the physical sciences. However, much of the literature has been focused on the upper primary and secondary years. This project adds to the current misconception literature by studying the student responses of over 8 000 middle primary aged students. The instrument used in this study is a multiple choice assessment delivered both on paper and online. Since this data is sourced from the middle primary cohort, this work may be particularly useful for those teaching and preparing science resources for primary students.

Introduction:

Students often develop incorrect ideas about physical science phenomena before they enter the classroom. These misconceptions, also known as alternative conceptions or children's science, have been studied since the 1970s. The recent AAAS 2061 project focused on the misconceptions held by upper primary to secondary year students (AAAS, n.d.). Our work will add to this research by targeting middle primary year students. It will draw from the responses of Grade 3 students who completed online multiple choice assessment in the physical sciences, between 2013 and 2018.

Over 8 000 students completed online multiple choice assessment where the distractors for the multiple choice items included common misconceptions. This technique has been used successfully by previous researchers (Burgoon, 2011; Gronlund, 2003; Treatgust, 1986).

Methods:

Participants: Over 8 000 Grade 3 students from public and private schools.

Instrument: Paper and online based multiple choice test. Often, the distractors in the multiple choice questions were common science misconceptions. The content and skills needed to answer the questions were aligned with the students' curriculum and/or the science practice skills outlined in the TIMSS 2019 Framework.

Since many of the distractors were common science misconceptions, determining the percentage of students that chose the misconception was simply a matter of selecting the number of students that chose that distractor divided by the total number of students that answered the question. In some cases students chose not to answer the question - these students weren't included in the analysis as their reason for not answering the question was unknown.

Results:

From our work the following misconceptions have been identified:

- Bigger objects always have more mass than smaller objects
- Air has no mass

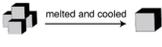
Mass

This study identified a misconception related to mass: *bigger objects always have more mass than smaller objects*. Evidence for this misconception can be seen from the students' responses to the item.

Students were asked how the mass of one large block compares to four small blocks. They were then given four multiple choice options, of which one contains the misconception that bigger objects have more mass (Option B).

This question was on tests administered in 2013, 2014, 2016 and 2018. Students select B 25% to 29% of the time. Most students choose the key, but the distractor containing this misconception is the second most popular choice.

The four blocks were melted and shaped into one new block.



How will the weight of the new block compare to the weight of four smaller blocks?

The weights will be the same.

The new block will weigh more than the four small blocks.

The four small blocks will weigh more than the new block.

It is not possible to tell which weighs the most.

YEAR	N	% MISC	% KEY
2018	2049	29	47
2016	2231	25	52
2014	2209	26	48
2013	1944	29	44

N = number of students who answered the item

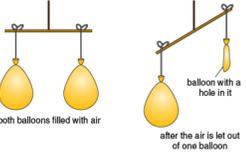
% = percentage of students that chose the misconception distractor/s

The probability of a student selecting a particular option versus their latent trait (ability) was plotted for students who attempted the question, and a Rasch model used to fit the data. The Rasch modelling was an excellent fit indicating that students with high ability realised that an object being large does not necessarily mean it weighs the most. This misconception is likely to only affect those students with lower abilities.

Gases

This study identified another misconception: *air has no mass*. Evidence for this misconception can be seen from the 2018 Grade 3 students' responses.

A girl has two identical balloons. She fills the balloons with the same amount of air. She ties the balloons to a balance. She makes a hole in one balloon to let the air out.



What does this experiment show? Choose the correct row.

	air has mass	air has volume
<input type="radio"/>	no	no
<input type="radio"/>	no	yes
<input type="radio"/>	yes	no

YEAR	N	% MISC	% KEY
2018	2042	31	26

Students were asked to identify whether air has mass. They were given four multiple choice options, of which two contain the misconception "air has no mass" (Options A and B). Of the students who responded, over 600 selected the distractors (31%). Only 26% of students selected the Key (Option D).

The misconception 'air has no mass' was held by 31% of the Grade 3 students who participated in the assessment. The AAAS 2061 Project highlights that this misconception affects 31% of their students in Grades 6-8 and 30% of students in Grades 9-12 (EGM064, AAAS Project 2061 (n.d.)). Noting that misconceptions often traverse culture and language, it would appear that this misconception emerges in the early primary years and remains throughout the entirety of students' schooling.

Conclusions:

Two misconceptions around physical sciences have been identified for Year 3: *bigger objects always have more mass than smaller objects* and *air/gas has no mass*.

What is also interesting to note is that the air has no mass misconception affected 30% of the middle primary school students in this study, and according to the AAAS 2061 Project report, it continues to affect 30% of secondary school students. This would indicate that a concerted effort is still required to change students' thinking on this concept.

References:

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Burgoon, J.N., Heddle, M.L. & Duran, E. (2011). Re-Examining the Similarities Between Teacher and Student Conceptions About Physical Science. *Journal of Science Teacher Education*, 22, 101-114.

Gronlund, N. (2003). *Assessment of student achievement*. Boston: Allyn and Bacon.

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