

Letter to the Editor

Re: Misconceptions Are “So Yesterday!”

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Dear Editor:

Maskiewicz and Lineback (2013) have written a provocative essay about how the term *misconceptions* is used in biology education and the learning sciences in general. Their historical perspective highlights the logic and utility of the constructivist theory of learning. They emphasize that students' preliminary ideas are resources to be built upon, not errors to be eradicated. Furthermore, Maskiewicz and Lineback argue that the term *misconception* has been largely abandoned by educational researchers, because it is not consistent with constructivist theory. Instead, they conclude, members of the biology education community should speak of *preconceptions*, *naïve conceptions*, *commonsense conceptions*, or *alternative conceptions*.

We respectfully disagree. Our objections encompass both the semantics of the term *misconception* and the more general issue of constructivist theory and practice. We now address each of these in turn. (For additional discussion, please see Leonard, Andrews, and Kalinowski, “Misconceptions Yesterday, Today, and Tomorrow,” *CBE—Life Sciences Education [LSE]*, in press, 2014.)

Is *misconception* suitable for use in scholarly discussions? The answer depends partly on the intended audience. We avoid using the term *misconception* with students, because it could be perceived as pejorative. However, connotations of disapproval are less of a concern for the primary audience of *LSE* and similar journals, that is, learning scientists, discipline-based education researchers, and classroom teachers.

An additional consideration is whether *misconception* is still used in learning sciences outside biology education.

Maskiewicz and Lineback claim that *misconception* is rarely used in journals such as *Cognition and Instruction*, *Journal of the Learning Sciences*, *Journal of Research in Science Teaching*, and *Science Education*, yet the term appears in about a quarter of the articles published by these journals in 2013 (Table 1). In almost all instances, the authors deployed the word unapologetically, not stating any reservations regarding its appropriateness (see also National Research Council, 2012).

A final consideration is whether any of the possible *alternatives* to *misconception* are preferable. We feel that the alternatives suggested by Maskiewicz and Lineback are problematic in their own ways. For example, *naïve conception* sounds more strongly pejorative to us than *misconception*. *Naïve conception* and *preconception* also imply that conceptual challenges occur only at the very beginning stages of learning, even though multiple rounds of conceptual revisions are sometimes necessary (e.g., see figure 1 of Andrews *et al.*, 2012) as students move through learning progressions. Moreover, the terms preferred by Maskiewicz and Lineback are used infrequently (Table 1) and may be perceived as jargon by many readers of *LSE*, whereas *misconception* is less cryptic to the average university faculty member. Thus, despite its history and its limitations, the word *misconception* remains a staple of science education research, and its use should continue.

Our concerns extend beyond the word *misconception* to a broader debate on constructivism. Table 2 presents several recent *LSE* papers that, in Maskiewicz and Lineback's opinion, ignore or misunderstand constructivist theory. Maskiewicz and Lineback do not identify the specific passages they find problematic, but we infer from their use of Smith *et al.* (1993) that they object to statements that *misconceptions* should be actively confronted, challenged, overcome, corrected, and/or replaced (Table 2). Smith *et al.* (1993) argue on theoretical grounds that confrontation does not allow refinement of students' pre-existing, imperfect ideas; instead, the students must simply choose among discrete prepackaged ideas. From Maskiewicz and Lineback's perspective, the papers listed in Table 2 are flawed because they accept or promote confrontation.

Our own stance differs from that of Maskiewicz and Lineback, reflecting a lack of consensus within constructivist theory. We agree with those who argue that, not only are confrontations compatible with constructivist learning, they

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Table 1. Use of the term *misconception* in selected education research journals in 2013

Journal (total articles published in 2013 ^a)	Articles using <i>misconception</i> ("nondisapproving" articles/total articles)	Articles using other terms
LSE (59)	23/24	<i>Alternative conception</i> (4) <i>Commonsense conception</i> (2) <i>Naïve conception</i> (1) <i>Preconception</i> (4)
<i>Cognition and Instruction</i> (16)	3/3	None
<i>Journal of the Learning Sciences</i> (17)	4/4	<i>Commonsense science knowledge</i> (1) <i>Naïve conception</i> (1) <i>Prior conception</i> (1)
<i>Journal of Research in Science Teaching</i> (49)	11/13	<i>Commonsense idea</i> (1) <i>Naïve conception</i> (1) <i>Preconception</i> (5)
<i>Science Education</i> (36)	10/11	<i>Naïve conception</i> (1)

^aAs of November 25, 2013. Does not include very short editorials, commentaries, corrections, or prepublication online versions.

are a central part of it (e.g., Gilbert and Watts, 1983; Hammer, 1996). We note that Baviskar *et al.* (2009) list "creating cognitive dissonance" as one of the four main tenets of constructivist teaching. Their work is consistent with research showing that focusing students on conflicting ideas improves understanding more than approaches that do not high-

light conflicts (e.g., Kowalski and Taylor, 2009; Gadgil *et al.*, 2012). Similarly, the *Discipline-Based Education Research* report (National Research Council, 2012, p. 70) advocates "bridging analogies," a form of confrontation, to guide students toward more accurate ways of thinking. Therefore, we do not share Maskiewicz and Lineback's concerns about the papers listed

Table 2. Papers cited by Maskiewicz and Lineback (2013) as using outdated views of *misconceptions*^a

Article	Example of constructivist language	Example of language suggesting confrontation
Andrews <i>et al.</i> , 2011	"Constructivist theory argues that individuals construct new understanding based on what they already know and believe... We can expect students to retain serious <i>misconceptions</i> if instruction is not specifically designed to elicit and address the prior knowledge students bring to class" (p. 400).	Instructors were scored for "explaining to students why <i>misconceptions</i> were incorrect" and "making a substantial effort toward correcting <i>misconceptions</i> " (p. 399). " <i>Misconceptions</i> must be confronted before students can learn natural selection" (p. 399). "Instructors need to elicit <i>misconceptions</i> , create situations that challenge <i>misconceptions</i> ." (p. 403).
Baumler <i>et al.</i> , 2012	"The last pair [of students]'s response invoked introns, an informative answer, in that it revealed a <i>misconception</i> grounded in a basic understanding of the Central Dogma" (p. 89; acknowledges students' useful prior knowledge).	No relevant text found
Cox-Paulson <i>et al.</i> , 2012	No relevant text found	This paper barely mentions <i>misconceptions</i> , but cites sources (Phillips <i>et al.</i> , 2008; Robertson and Phillips, 2008) that refer to "exposing," "uncovering," and "correcting" <i>misconceptions</i> .
Crowther, 2012	"Prewritten songs may explain concepts in new ways that clash with students' mental models and force <i>revision</i> of those models" (p. 28; emphasis added).	"Songs can be particularly useful for countering... conceptual misunderstandings... Prewritten songs may explain concepts in new ways that clash with students' mental models and force revision of those models" (p. 28).
Kalinowski <i>et al.</i> , 2010	"Several different instructional approaches for helping students to change <i>misconceptions</i> ... agree that instructors must take students' prior knowledge into account and help students integrate new knowledge with their existing knowledge" (p. 88).	"One strategy for correcting <i>misconceptions</i> is to challenge them directly by 'creating cognitive conflict,' presenting students with new ideas that conflict with their pre-existing ideas about a phenomenon... In addition, study of multiple examples increases the chance of students identifying and overcoming persistent <i>misconceptions</i> " (p. 89).

^aWhile these papers do not adhere to Smith *et al.*'s (1993) version of constructivism, they do adhere to the constructivist approach that advocates cognitive dissonance.

in Table 2. To the extent that these papers are about *misconceptions*, they seem consistent with forms of constructivism that incorporate confrontation.

Above all, science is about evaluating competing ideas. We help our students when we teach them how to improve their understanding of the natural world by comparing hypotheses. As instructors, our task is to provide a safe, supportive environment in which students can grapple with challenging, conflicting ideas and undergo mini-paradigm shifts (e.g., Price, 2012). We embrace collegial disagreement.

Maskiewicz and Lineback imply that labeling students' ideas as *misconceptions* essentially classifies these ideas as either right or wrong, with no intermediate stages for constructivist refinement. In fact, a primary goal of creating concept inventories, which use the term *misconception* profusely (e.g., Morris *et al.*, 2012; Prince *et al.*, 2012), is to demonstrate that learning is a complex composite of scientifically valid and invalid ideas (e.g., Andrews *et al.*, 2012). A researcher or instructor who uses the word *misconceptions* can agree wholeheartedly with Maskiewicz and Lineback's point that *misconceptions* can be a good starting point from which to develop expertise.

As we have seen, *misconception* is itself fraught with *misconceptions*. The term now embodies the evolution of our understanding of how people learn. We support the continued use of the term, agreeing with Maskiewicz and Lineback that authors should define it carefully. For example, in our own work, we define *misconceptions* as inaccurate ideas that can predate or emerge from instruction (e.g., Andrews *et al.*, 2012). We encourage instructors to view *misconceptions* as opportunities for cognitive dissonance that students encounter as they progress in their learning.

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