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Discussion

Making Science Education More Natural – Some Ideas from the Argumentative Theory of Reasoning

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Abstract: The benefits of the exchange of arguments for science education are well established. The argumentative theory of reasoning is in a good position to explain these benefits. It claims that the main function of reasoning is to argue: to produce arguments to convince others, and to evaluate others' arguments in order to be convinced when, and only when, warranted. This theory explains why solitary reasoning often leads to poor reasoning performance, while the social exchange of arguments often leads to good reasoning performance. It also suggests that the best way to learn how to reason well is to reason with others. In this article, I attempt to integrate the findings from the other articles of the special issue into this framework.

Keywords: reasoning, argumentation, argumentative theory of reasoning, collaborative learning

Science education praxisnah – Ideen aus der Argumentative Theory of Reasoning

Zusammenfassung: Dass der Austausch von Argumenten sehr nützlich für die Vermittlung wissenschaftlicher Denkweisen ist, konnte bereits nachgewiesen werden. Die Argumentative Theory of Reasoning kann diesen Nutzen gut erklären. Sie besagt, dass die Hauptfunktion des schlussfolgernden Denkens das Argumentieren ist: Argumente zu produzieren, um andere zu überzeugen, und die Bewertung von Argumenten anderer, um überzeugt zu werden. Diese Theorie erklärt, warum individuelles Argumentieren häufig nur zu einer schlechten Argumentationsleistung führt, während der soziale Austausch von Argumenten zu einer besseren Argumentationsleistung führt. Zusätzlich weist sie darauf hin, dass die beste Art zu lernen wie man gut argumentiert, darin besteht, mit anderen zu diskutieren. In diesem Artikel versuche ich, die Erkenntnisse der anderen Artikel dieses Themenhefts in diesen Rahmen zu integrieren.

Schlüsselwörter: Schlussfolgern, Argumentation, argumentative theory of reasoning, kollaboratives Lernen

Science is not the province of the solitary genius. It is a collaborative enterprise. Not only in the obvious sense that we need many people to build a hadron collider, but also that ideas are often built collaboratively, as scientists exchange arguments with each other. Argumentation is omnipresent in science, from books to informal chats, from seminars to lab meetings. It fosters the development of new ideas (e.g. Beller, 2001), enables the spread of the best ideas (Kitcher, 1993; Mercier & Heintz, 2014), and teaches junior scientists how to do their job well (Dunbar, 1995).

Argumentation is also critical when students learn about science, from primary school (Perret-Clermont, 1980) to college (Smith et al., 2009). The learning gains from collaborative learning are uncontroversial (Slavin, 1995), and the role of the exchange of arguments in these gains is increasingly recognized (Mercier, 2011; Nussbaum, 2008).

What explains these benefits of argumentation? A recent theory bearing on the function of human reasoning – the argumentative theory of reasoning – offers some suggestions.

Reasoning can be defined as the set of cognitive mechanisms that enable the use of reasons – the production and evaluation of reasons. Reasoning bears in particular on reasons produced to make us change our mind about the conclusion they support – otherwise, we are dealing with justifications.

The dominant view of the function of reasoning, in psychology and philosophy, is that it serves an individual meliorative function. By examining the reasons for their beliefs and decisions, lone reasoners ought to be able to improve on these beliefs and decisions. However, decades of results in experimental psychology reveal an abysmal track record for solitary reasoning. Instead of reasoning objectively, people overwhelmingly find arguments that support their preconceived ideas (people have a myside bias, see Mercier, in press). People use the laxest criteria when deciding what counts as a good reason for their be-

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liefs (people reason lazily, see Trouche, Johansson, Hall, & Mercier, in press). As a result, they tend to produce mediocre arguments (Kuhn, 1991; Perkins, 1989) that are more likely to prop up their existing beliefs than to correct them, whether they are right or wrong (e.g. Evans & Wason, 1976).

As the name suggests, the argumentative theory of reasoning (ATR) claims that the main function of reasoning is to argue: to produce arguments to convince others, and to evaluate others' arguments in order to be convinced when, and only when, warranted (Mercier & Sperber, 2011). If the function of reasoning, when it produces arguments, is to convince others, then the myside bias makes sense: conviction is best achieved with arguments for our point of view, not for our interlocutor's point of view. Laziness also makes sense. In a dialogic context, it is more efficient to start with a relatively weak, generic argument (Mercier, Bonnier, & Trouche, in press). If the argument is sufficient, then any extra effort would have been wasted. If the argument proves insufficient, the interlocutor typically provides a counter-argument. It is then much easier to address this counter-argument than it would have been to anticipate it.

By contrast with argument production, argument evaluation should be both unbiased and exigent. Unbiased so that we accept good arguments even if they challenge our beliefs. Exigent so that we reject weak arguments and are not misled by fallacies. Indeed, people seem to be quite good at evaluating arguments (Mercier & Sperber, 2011).

In solitary reasoning, people only produce arguments. By contrast, in an argumentative discussion, people take turn producing and evaluating arguments. Arguments from all present points of view are heard, poor arguments are shot down, and, in most cases, the best arguments carry the day. This is why argumentation enables the spread of the best answers in groups (Moshman & Geil, 1998; Trouche, Sander, & Mercier, 2014). When the best answer can be supported by good arguments, groups vastly outperform individuals, even, in some cases, the best individual performers (Laughlin, 2011).

Felicitous argumentative contexts offer many cognitive advantages. For instance, students who exchange arguments with each other not only tend to accept the correct answer, but they reach a deeper understanding of the reasons behind the correct answer (e.g. Nussbaum, 2008; Smith et al., 2009). This might be because they do not take each other's word for granted. When a student tells a peer that he's wrong, he has to be convinced before he changes his mind – he has to understand why he should change his mind. By contrast, students are more likely to take the teacher's word for it and to pay less attention to her explanations, since they have already accepted that her answer is correct. Argumentation also helps students produce better arguments. For instance, having to argue with their peers can help students rely more on evidence to address contrasting points of view, and to create links between evidence and conclusions that are both clearer and more complex (Mayweg-Paus & Macagno, 2016).

Although the ATR predicts that reasoning should provide sounder results when people exchange arguments with each other than when they reason on their own, this is not an absolute rule. First, this doesn't mean that argumentation is a silver bullet. Students might not have the proper motivation. This can happen for instance if they all agree with each other, in which case argumentation might be deleterious, as it reinforces their beliefs instead of questioning them, even if they are wrong. Students might also be more motivated to *justify* their point of view than to *argue* for them.

So far, we have assumed that when students exchange reasons, they do so to convince each other to adopt a given opinion. However, students also exchange reasons to justify their opinions. When they do so, their goal is not get other students to share their opinion, but to get them to accept that holding this opinion is rational. Conviction and justification are best served by different reasons. The premise of a justification should be plausible for the individual offering the justification, while the premise of an argument should be plausible for the individual receiving the argument. In other words, good justifications should be self-centered, while good arguments should be audience-centered.

When students are asked to discuss scientific topics, or the answer to a question in a science class, they might not care much about convincing others to share their views. However, they probably care what others students think of them. As a result, they might be more inclined to offer justifications than arguments. This might explain why students spontaneously offer reasons that support their opinion rather than reasons that attack others' opinions (e.g. Kuhn & Udell, 2007). This issue can be remedied in different ways. One way would be to manipulate the context so that students have more incentives to want others to share their opinions. Another is to present specific instructions to the students. For instance, students can be reminded, as they discuss, of the importance of paying attention to differences in opinions, which allows students to engage more with each other's views and arguments (Thiebach, Mayweg-Paus & Jucks, 2016).

Another misconception that might stem from the ATR is that if we are naturally endowed with reasoning skills, then there is no need for improvement. This is wrong – we are endowed with skills to learn a language, yet some learn it better than others. Crucially, thought, improvements in argumentative skills are most likely to arise from argumentation itself than from the solitary use of reasoning. Even

solitary reasoning benefits more from training in argumentation than in solitary reasoning (e.g. Kuhn & Crowell, 2011). Through the exchange of arguments, students also develop a more sophisticated epistemological stance (Iordanou, 2016). Congruent with the ATR, it seems that vocabulary knowledge – which is to a large extent a social skill, since it depends on the ability to learn what others mean (Bloom, 2002) – is a better determinant than analytical reasoning ability of the ease with which one's argumentative skills improve (Britt *et al*. this issue).

The final misconception I would like to address is that solitary reasoning is necessarily flawed. While the ATR suggests that reasoning didn't evolve primarily for private ratiocination, there are still contexts in which the ATR predicts that solitary reasoning can lead to good outcomes. One is when the students have no strong intuition regarding the correct answer to a problem, and they can easily access reasons that guide them towards the correct answer (e.g. Simonson & Nye, 1992). Another is when students think they know something, but in fact know so little that they cannot readily expand on the issue. Bromme, Thomm, & Ratermann (2016) find that asking students to explain their stance on socio-scientific topics led them to realize that they knew less than they thought about these topics.

I hope to have shown that the argumentative theory of reasoning can provide a useful framework for understanding how reasoning works in an educational context, and in particular how to make the best use of the exchange of arguments.

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