

Forms of Justification when Writing Scientific Arguments

Students whose ability is at the lowest level are not able justify their claim, and, thus, do not construct an argument, or the students justify their claim with epistemically less important forms (e.g. they do not provide empirical evidence). However, research suggests that when writing scientific arguments students often try to use data to support their claims (Sandoval & Millwood, 2005). Therefore, it is likely that some students might include a mixture of empirical data and less important forms. The ability of students who do this is at one of the highest two levels. If the less important forms are additive to the argument then the students' ability is in line with the *more important justifications* level. For instance, the student may make an empirical argument and then further support that with something an expert said. It is only at the highest level that students are able to critique forms of justification because they limit the forms of justifications used to only those that strengthen the quality of their argument. If instead, the student relies on a less important form of justification in addition to empirical data, and the less important form(s) detract(s) from the argument's quality, then the student's ability is at the *mixture of justifications* level. For instance, suppose a student makes an empirical argument and then tries to further support her argument with something an expert said, but the latter is irrelevant. In this case, the authority statement is detracting from the quality of the argument, despite having high quality evidence. The distinction between the *more important justifications* and *mixture of justification* levels can be thought of in terms of depth versus breadth. Namely, if a student adds less important justifications that are not connected to the more important justifications in order to add breadth to the argument, then their writing would be at the *mixture of justifications* level. In comparison, when a student adds less important justifications to more important justification to impart a deeper more nuanced argument, then their writing would be at the *more important justifications* level.

Forms of justification construct map for the writing assessments

| Levels | Description |
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| High | Student limits all of the scientific evidence to the most important forms (empirical measurements and observations). |
| 3 More important justifications | OR Student provides more important forms (empirical measurements and observations) as well as some less important forms of scientific justifications (appeals to authority, prior experience), but the less important forms are used as additional support of the argument. |
| 2 Mixture of justifications | Student provides more important forms (empirical measurements and observations) as well as some less important forms of scientific justifications (appeals to authority, prior experience), but the less important forms do not support or do detract from the argument. |
| 1 Less important justifications | Student only provides less important forms of scientific justifications (e.g. appeals to authority, personal story, plausible mechanism). |
| Low | |

References

Sandoval, W. A., & Millwood, K. A. (2005). The quality of students' use of evidence in written scientific explanations. *Cognition and Instruction*, 23(1), 23-55.