Big data in educational science: Meta-analysis as an analysis tool

University of Zurich[UZH]

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Since the introduction of the term meta-analysis to the scientific community by Glass in 1976, the application of such analyses has increased. In educational science especially, meta-analysis has been promoted and expanded since that time. Meta-analysis is defined as a simple statistical aggregation of different studies on the same subject, to reach an overall conclusion. The results of single studies suffer, for example, from small sample sizes or inaccurate measures; these limitations are then overcome by a meta-analysis. The technology revolution through the introduction of computers and the internet has had a significant impact on science and analytic research. Since the beginning of the computer era, science databases have multiplied, and there is now more data available for analysis and interpretation. We now talk about the age of big data. As data is nowadays often seen as having the same potential as oil, for countries and for the world, the question arises: Do we really take advantage of our era's golden oil products? In our research, we argue that meta-analysis could be a solution for the analysis of big data in educational issues, allowing us to reveal research gaps. To guide interested readers, we take teachers' judgment achievement as an example. We begin by describing the current state of teachers' judgment achievement research by meta-analysis. Due to conclusions from meta-analyses on teachers' judgment accuracy, we introduce lens model studies and show their practical potential for guiding policies and practices. Finally, we end with an outlook for our current research projects on big data within the educational field.

Teachers' judgment achievement by meta-analysis

Teachers must regularly evaluate students' skills and motivation (see Figure 1 and 2). Part of a teacher's daily business is judgment and decision-making, which is a basic teaching skill and a common part of teacher education programmes. Inaccurate judgments can result in conditions that prevent students from reaching their full potential and can increase inequality between students' rate of learning and development. Previous meta-analyses have concluded that, perhaps unsurprisingly, there is substantial variance in the accuracy of teachers' judgments, or teachers' judgment achievement, and that the correlation between teachers' judgment and other indicators like test scores or grades is far from perfect (Hoge & Coladarci, 1989; Südkamp, Kaiser, & Möller, 2012). Hence, understanding how to improve teachers' judgment achievement is a critical area of research. To date, however, little is known about what can be done to ensure that teachers make the most accurate decisions possible, and substantive conclusions about teachers' judgment achievement have not been reached through existing meta-analyses.

Shortcomings: Revealing the black box by the lens model approach

The framework of the Social Judgment Theory is based on research by Egon Brunswik (see Hammond & Stewart, 2001). This background provides the basis for revealing components underlying teachers' judgment inaccuracy by the

Figure 1. Typical school-day situation of a teacher.

so-called Lens Model. In a typical lens model study, a judge must make a number of decisions based on different pieces of information ("cues"). Judgment achievement is measured by the extent to which the judge's conclusion matches (i.e., correlates) with the actual outcome or situation ("criterion"). To explain the lens model in detail, we introduce it by an example within educational science. A study by Cooksey, Freebody, and Davidson (1986) provides an example of a typical lens model study (see Figure 3). In this study, 20 teachers evaluated children's reading comprehension based on 118 profiles of kindergarten children, including five important pieces of information – so-called cues (see Figure 3, $X_{1\text{-}k}$, e.g., reading-ability, oral language ability, socio-economic status). Teachers' judgments (see right side of Figure 3, Rs) were compared with the actual test score on a reading comprehension test (see the left side of Figure 3, Re), which is also used in studies outside the lens model approach (see Hoge & Coladarci, 1989; Südkamp et al., 2012), i.e., studies summarised by the meta-analyses discussed above. If there is a high correlation between teachers' judgment and the test criterion, the teachers' judgment is deemed to be accurate.

Lens model equation

One unique advantage of lens model studies is that they reveal the underlying reasons for judgment inaccuracy, and hence they enhance the knowledge gained from previous meta-analyses in the field. The lens model (Figure 3) is the basis for the Lens Model Equation (LME). (For more background information on the LME, see Hammond & Stewart, 2001). In brief, the

Figure 2. Typical school-day situation of a teacher.

LME mathematically describes judgment achievement (ra) (i.e., the correlation between a person's judgments and a particular criterion) in terms of four components. For practical reasons, we introduce the two main components in the following, namely the task predictability (Re) component and the consistency component (Rs).

The task predictability component (Re) references the extent to which the available information for a teacher correlates with test scores on a reading comprehension test, or in other words, the extent to which a decision can be made based on the information available. This information is important especially for technical methodologies, as their main focus is on task improvements. This component gives technical methodologists a hint as to whether the given task is ideal for judging teachers' accuracy. If this task component is low, it indicates that perhaps more or different types of information (cues) are needed for a teacher to judge the task accurately.

Another important component is the consistency (Rs) component, which refers to the reliability of judgments, that is, the extent to which a judge reliably reaches the same decision based on the same pieces of information. For example, the component examines the extent to which a teacher reaches the same judgment based on profiles with similar information, i.e., the multiple correlation of the cues with the person's estimates. This component is of great value for teaching education. If the component is low, it means that teachers vary their judgment and are

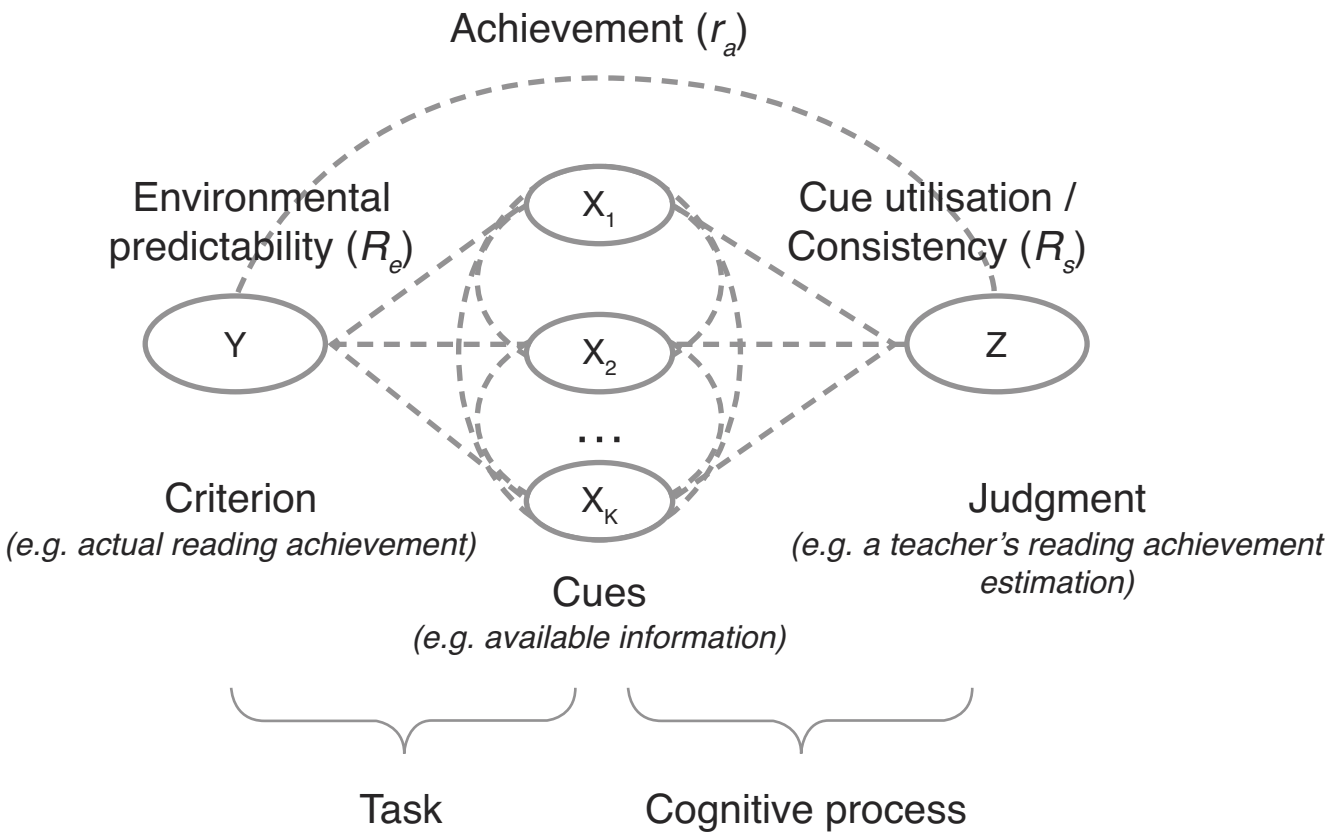

Figure 3. The lens model applied to teachers' judgment on reading comprehension (see Cooksey, Freebody, and Davidson, 1986).

inconsistent; although the task information is perfectly available, they sometimes use it and sometimes ignore it. Hence, this component would provide important information in teacher training, as to whether available information is used inconsistently or whether teachers already use the available information perfectly.

Expert models

The lens model approach is fruitful not only for revealing important components of teachers' judgment inaccuracy, but also for revealing whether teachers' evaluation could be replaced by an expert model (e.g., simple mathematical model). The idea of creating such models can be traced back to Meehl's (1954) evaluation of whether clinical psychologists outperform models. As introduced within the lens model approach, this can be used to create models and bootstrapping a judge by it. For a complete evaluation on the success of expert models within this approach, we refer to our previous study (Kaufmann & Wittmann, 2016).

Current project with Fordham University (US)

However, one way to potentially improve teachers' judgment achievement more immediately is to provide teachers with additional sources of advice, since judgments based on multiple opinions are usually more accurate than judgments made by one person alone (Galton, 1907; see also research on the wisdom of the crowd, e.g., Budescu & Chen, 2015). In our current project, we therefore investigate the extent to which teachers consider advice from so-called "expert models," or formal decision-making tools based on expert consensus and/or empirical research (e.g., an

equation). Evidence from other fields suggests that the acceptance of expert models vary widely. Importantly, although expert models may have the potential to improve teachers' judgment achievement, to date no research has examined the extent to which teachers actually consider advice from expert models. In our current projects, we experimentally check different conditions to improve teachers' judgment accuracy by advice (expert models). To check for any cultural differences, we initiated a collaboration project with Fordham University in the US. We will conduct a study with teachers in Switzerland and in the US. Following the "No Child Left Behind" initiative, teachers in the US have been confronted with student test scores as a type of feedback on their judgments and expectations. In contrast, teachers in Switzerland seldom encounter this kind of feedback. Comparing teachers in the US with teachers in Switzerland would therefore provide an indication of whether experience in getting advice and feedback is associated with the tendency to accept advice. We expect that teachers in the US will be more likely to integrate external sources of advice into their judgments relative to teachers in Switzerland. This collaboration project is funded by a short visit grant from the Swiss National Science Foundation (SNSF).

Practical implications for daily school life

Although the literature includes studies involving big data and meta-analysis within the area of teachers' judgment achievement, little is known about how teachers' judgment achievement can be improved. Our current project will provide new evidence about how external sources of advice, and in particular expert models, may help teachers make more accurate judgments. Our results will supplement recent reviews in the field by extending research on the use and acceptance of expert models to the educational field. Our project is particularly relevant for the educational field but may also stimulate similar projects in other applied areas, such as business or the medical sciences.

Helping teachers to make accurate judgments is already a core component of teacher education. Our research results will provide precise information about how advice from expert models may help to improve teachers' judgment achievement. Our current project is also relevant for evidence-based school development. Although there is an overall consensus that data feedback is necessary for school development, there is currently a lack of research on the type of data feedback (advice) most needed (see Altrichter, Moosbrugger, & Zuber, 2016). Our results will indicate whether expert models may be one type of advice that increases judgment accuracy and ultimately helps to improve schools.

Conclusion

Overall, our contribution shows that meta-analysis is a useful tool to use to analyse big data in educational science and reveal research gaps that might prompt the initiation of new studies. Hence, as data production and storage will continue to increase in the future, meta-analysis as a research tool will fruitfully enrich educational science. However, our contribution also shows that we urgently need research on how to handle feedback or advice by research (meta-analysis) so that the practical transfer of science takes place within the educational setting.

If you're interested in our research – as a teacher, policy maker, or researcher – we welcome your inquiries to provide additional specific information.

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Esther Kaufmann, PhD
Senior lecturer and researcher
Institute of Education,
University of Zurich (Switzerland)
Tel: +41 44 634 27 72
esther.kaufmann@ife.uzh.ch
http://www.ife.uzh.ch/en/research/teb/mitarbeitende3/kaufmannesther.html

Professor Dr Katharina Maag Merki
Chair
Institute of Education,
University of Zurich (Switzerland)
Tel: +41 44 634 27 80
kmaag@ife.uzh.ch
http://www.ife.uzh.ch/en/research/teb/mitarbeitende3/maagmerkikatharina.html


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