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Does the textbook matter? Longitudinal effects of textbook choice on primary school students' achievement in mathematics



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ABSTRACT

Mathematics textbooks are ascribed an important role for classroom practice. Until now there are still open questions concerning the genuine effect of textbooks on students' learning in mathematics. This paper examines the effect of different textbooks representing the same curriculum on the student achievement by reanalyzing a longitudinal data set on primary school students' mathematics skills from Grade 1 to 3 (N = 1664). Results from multilevel regression analyses showed that mathematics teachers' textbook choice has a substantial effect on the students' mathematics achievement and that individual textbooks substantially differ in their effects. Furthermore, there are indications that the effect of textbook choice is cumulative over the school years. The findings suggest that textbooks should be considered as an important covariate in educational research and that textbook choice is a relevant factor for educational practice.

1. Introduction

Mathematics textbooks have an important role in representing and translating the abstract curriculum into operations that teachers and students can carry out (Valverde, Bianchi, Wolfe, Schmidt, & Houang, 2002). They are extensively used in everyday classroom practice (Mullis, Martin, Foy, & Arora, 2012), differ in their content and pedagogical styles (Pepin & Haggarty, 2001) and therefore shape the potential learning opportunities for students. Hence, it is commonly assumed that textbooks have a substantial effect on student achievement. Presently, there is a lack of empirical evidence supporting this assumption. Research on textbook effects reveals conflicting results (van Steenbrugge, Valcke, & Desoete, 2013), and is often based on small sample sizes and cross-sectional designs (Fan, Zhu, & Miao, 2013). Many textbook studies – especially those with larger sample sizes – are in fact curriculum studies because the considered textbooks represent different curricula (e.g., standard based curriculum vs. traditional curriculum, Tarr et al., 2008; Koedel, Morgan, Polikoff, Hardaway, & Wrabel, 2017). The aim of the present study is therefore to examine the effect of different textbooks on student achievement, representing the same curriculum. The results are based on a reanalysis of a longitudinal data set on primary school students' mathematics skills from Grade 1 to 3.

1.1. Role of the textbook

Textbooks are artifacts since they are educational material created by human beings (e.g., Rabardel, 2002). They are written by an author or group of authors and produced by a publisher. The authors interpret a curriculum and transform it into learning opportunities and concrete operations that teachers and students can carry out (Valverde et al., 2002). Hence, a textbook can be described as a mediator between the intended curriculum as official policy and the implemented curriculum by the teachers (Valverde et al., 2002). Textbooks are therefore seen as conveyors of the curriculum and often referred to as curriculum material (e.g. Herbel-Eisenmann, 2007; Remillard, 2005). They offer teachers and students opportunities for teaching and learning by providing an objectively given didactical structure of the content. Textbooks thereby specify a certain manner of use and therefore limit possible uses (Remillard, 2005; Rezat, 2008).

Due to their mediating role between intended and implemented curriculum, textbooks can be used as a monitoring instrument in the educational system. In some countries textbooks must be approved and licensed by the ministry of education (e.g., Hong Kong, Norway), while in other countries there is no approving authority (e.g., The Netherlands, some states in the US) (Mullis et al., 1997). The strictness of monitoring by an authority can influence the curriculum interpretation in the textbook (Schmidt, Raizen, Britton, Bianchi, & Wolfe, 1997). Summarizing, mathematics textbooks are ascribed an important

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role for classroom practice (Pepin & Haggarty, 2001). Even though one can assume that teachers and students modify the offered learning opportunities in textbooks, it is assumed that textbooks exert influence on the teaching and learning in the classroom (Valverde et al., 2002).

1.2. Textbook content

Textbooks are artefacts and therefore historically developed, culturally formed, produced for certain ends and used with particular intentions (Rezat, 2008). Research shows that mathematics textbooks differ in their mathematical content as well as in certain pedagogical, cultural and sociological aspects (e.g., related to gender, ethnicity, equity, Fan et al., 2013). For example, cross-national comparisons revealed that mathematics textbooks vary across different countries or states due to specific cultural and educational traditions (Mayer, Sims, & Tajika, 1995; Pepin & Haggarty, 2001). Studies regarding the mathematical content indicate variations between textbooks concerning the interpretation of a curriculum (Fan et al., 2013). Differences occur, for example, with respect to the structure of the presented mathematical topic (e.g., Jones et al., 2015, for the statistical content in 25 primary school textbooks in Texas) and the cognitive demands of the learning opportunities (e.g., Kolovou, van den Heuvel-Panhuizen, & Bakker, 2009, for cognitive demands of number problems in the six main textbook series used in Dutch primary schools). To conclude, textbook differences are based on different curriculum interpretations following different pedagogical intentions, cultural or educational traditions. This generates different conditions for students' mathematics learning, depending on the teachers' use of textbooks for lesson preparation.

1.3. Use of the textbook in teaching and learning

Several studies revealed that teachers frequently use mathematics textbooks as the main basis for their instruction. For example, according to the Trends in International Mathematics and Science Study (TIMSS) 2011 on average about 75% of the primary school teachers base their instruction on the mathematics textbook. In Germany 86% of the teachers report using the mathematics textbook as a basis of instruction (Mullis, Martin, Foy, & Drucker, 2012). Lepik, Grevholm, and Viholainen, (2015) analyzed surveys from 402 mathematics teachers of Grade 7 to 9 from Estonia, Finland and Norway. Depending on the country, 49–64% of the teachers rely heavily on the textbook in terms of planning and preparing their lessons. Furthermore 79–92% of the teachers use the textbook as the only source for exercises in at least half of the lessons. Krammer (1985) analyzed data from systematic lesson observations of 50 mathematics teachers from 17 schools in the Netherlands which used one of the three best known Dutch mathematics textbooks. The results indicated that users of different textbooks implement different teaching practices. Evidence for a consistency of the relationship between textbook features and teaching practices is also provided by data from TIMSS 1995 and the related video study. The analyses of the United States TIMSS eighth grade data revealed a positive relation between the space a topic covers in a textbook and the instructional time teachers using this textbook have dedicated to this topic in the mathematics classroom (Schmidt et al., 2001). Mathematics textbooks influence what topics are covered and how these topics are presented. It was concluded that mathematical topics covered in given curriculum materials are considered of fundamental importance by the teachers (Stein, Remillard, & Smith, 2007), whereas there is a low probability that topics not covered in the textbook will be presented in the classroom (Schmidt et al., 1997).

The mathematics textbook is not only an important resource for teachers, but also for students. Although curriculum guides usually define the official curriculum for students, many students are not even aware of them (Schmidt et al., 1997). Textbooks on the other hand are a basis for everyday school practice (Mullis, Martin, Foy, Arora et al., 2012; Mullis, Martin, Foy, Drucker et al., 2012; Schmidt et al., 2001). In

their study Lepik et al. (2015) found that most problems for students' in-class exercises and homework were taken from mathematics textbooks. Furthermore, 45% (Norway) to 76% (Finland) of the teachers used the textbook as the only source for homework. According to TIMSS 1995 students of most western countries report that they also work from textbooks or work cards on their own in most lessons (e.g., England 49%, United States 57%, New Zealand 50%).

In summary it can be stated, that mathematics textbooks are an important and extensively used resource for teaching and student learning.

1.4. Influence of textbook choice on students' mathematics achievement

Schmidt et al. (2001) analyzed the United States TIMSS 1995 eighth grade data and found a direct relation between the amount of space allocated to covering a topic and the size of students' achievement gain on that topic. Similar findings regarding the interaction between learning opportunities in mathematics textbooks and learning outcomes were reported by Törnroos (2005). Törnroos examined the influence of nine mathematics textbooks series used in the classes of the TIMSS 1999 sample in Finland on students' achievement in the TIMSS mathematics test. It turned out that the number of learning opportunities a textbook provided specifically for the content of TIMSS items was significantly positively correlated with students' performance in the TIMSS test. Furthermore Hadar (2017) analyzed whether opportunities to engage in tasks demanding different levels of understanding provided in mathematics textbooks correlate with students' achievements on tasks demanding equivalent levels of understanding on a standardized national exam. She examined two 8th grade mathematics textbooks used by students in the Arab community in Israel. Using a sample of all 8th grade students in the Arab community who completed the national math test in 2015 and studied in schools using one of the two textbooks (N = 4040 students) Hadar found that students using a book will have higher scores if this textbook provides the opportunity to engage in tasks demanding higher levels of understanding. In contrast to this results, a study of van Steenbrugge et al. (2013) in Flanders (Belgium) did not find substantial differential effects of mathematics textbooks on students' achievement. The cross-sectional study included 1579 students (Grade 1–6) and their 89 teachers using five different mathematics textbook series. The authors conclude that “Up to date there is no agreement about the differential impact of mathematics textbooks on students' performance results” (van Steenbrugge et al., 2013, p. 346).

The previously presented research indicates that there are still open questions concerning the genuine effect of textbooks on students' learning in mathematics. Many research studies have limitations due to small sample sizes and/or cross-sectional designs (cf. the review article Fan et al., 2013). In the US, textbook effects were analyzed with adequate sample sizes in the context of curriculum research (e.g., Tarr et al., 2008; Koedel et al., 2017). However, the textbooks in these studies served as indicators for the implementation of different curricula and, consequently, the authors interpreted the effects on students' mathematics achievement as curriculum effects. Fan et al. (2013) concluded in their review of research focusing on mathematics textbooks that there is still a strong need for more confirmatory research about the relationship of mathematics textbooks and student achievement. Five years later to the best of our knowledge, there are no large longitudinal studies examining genuine textbook effects (i.e., effects of textbooks representing the same curriculum) on students' mathematics achievement.

1.5. The present study

We analyzed data of a three-year longitudinal study in primary school comprising teacher information as well as student information including arithmetic skills from Grade 1 and 2 as well as the students'

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