Studies on Effective Interventions to Improve Math Learning

in Low- and Lower-Middle-Income Countries

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Abstract of the Dissertation

With the efforts of the international community, access to primary education significantly expanded in developing countries since the 1990s. The net enrollment rate in primary education in low-income countries improved from 60 percent in 1999 to 83 percent in 2012. Despite the remarkable progress in access to primary education, the quality stagnated in developing countries. According to the estimate of UNESCO, over 600 million children of primary and lower secondary school age are not reaching the minimum proficiency levels in reading and mathematics in low- or lower-middle-income countries. Most of those children are living in low- or lower-middle-income countries. The situation wherein a large number of children spend years in school without gaining foundational skills is called the "learning crisis."

This dissertation presents evidence pertaining to the two different packages of interventions that aim to improve math learning in basic education. Both packages were developed in technical cooperation by the Japan International Cooperation Agency (JICA), a bilateral aid agency of the government of Japan. The agency conducted a series of projects on technical cooperation in basic education in Central America and West Africa since the 2000s. One of the packages was developed in El Salvador, which was composed of distribution of learner-friendly math textbooks and other related components, such as introductory teacher training. The math textbooks covered from the first grade in primary to the last grade in secondary education. Subject contents of mathematics were carefully

subdivided considering the student assessment, and the contents were sequenced in the textbook to assure small-step learning by students. The textbooks were also designed to facilitate lessons in which students engaged in learning mainly through problem solving.

The other package of interventions was developed in Niger, which was composed of a series of training for the school management committee (SMC), and a provision of math workbooks accompanied with a training for teachers and community volunteers. SMC was composed of the school principal and representatives from teachers, parents, and community members. After the training for SMC executive members, the SMC organized a community general assembly where it shared a summary of math assessment results with parents, teachers, and community members. The committee facilitated discussions on the development of joint action plans integrating extra-curricular remedial activities using math workbooks. Math workbooks were self-learning materials for students, which were distributed for schools by the Ministry of Education. Students received workbooks that matched their learning levels and studied math at their own pace. Teachers and community volunteers took on the role of activity facilitators of checking students' answers and giving them instructions. The package was scaled up by the Ministry of Education in Niger to cover around 3,500 schools in the Tillaberi region in 2018.

This dissertation utilizes data collected by the JICA supported projects in El Salvador and Niger, and rigorously estimates the impact of the package of interventions on student math learning. In El Salvador, the Ministry of Education and JICA jointly conducted a randomized controlled trial (RCT) to measure the impact of the package of interventions on student math learning. The experiment targeted 2nd grade in primary education, and 7th grade in lower secondary education. In a series of survey, same students were tracked for two years, 2018 and 2019.

In Niger, JICA supported project conducted a series of survey for sampled schools. Originally, the package of interventions targeted all the six grades in primary education. But due to budget constraints, the distribution of math workbooks was limited to students from the 1st to 4th grades only. Focusing on the difference in the intervention, this dissertation estimates the causal impact of the

package of interventions on 4th grade student math learning in comparison with 5th grade students using the difference in differences (DD) strategy.

This dissertation contributes to the literature on international educational development by demonstrating evidence pertaining to the two complementary packages of interventions to improve math learning, and exploring the external validities for other contexts. The package of interventions developed in El Salvador mainly targeted the improvement of math learning in regular classes. On the other hand, the package of interventions developed in Niger focused on extra-curricular remedial activities in math. Whereas the former package of interventions covered math curricula, the latter focused on basics in mathematics, numbers and four basic operations.

A popular approach to exploring the external validity of evidence is the systematic review that synthesizes evidence from different countries; however, the policy implications from the reviews are often too broad to apply to specific contexts. Therefore, instead of attempting a systematic review, this dissertation uses a method called "mechanism mapping" proposed by Williams (2020) so that the external validities of the evidence from El Salvador and Niger can be explored. The method begins by laying out a theory of change of the intervention. Subsequently, important contextual assumptions related to each step in the causal chain are raised. Finally, actual contextual situations are laid out corresponding to the contextual assumptions. The differences between the contextual assumptions and actual situations indicate the parts in a theory of change, which should be examined and adapted to the actual context. The evidence pertaining to the two packages and examination of the external validities jointly suggests hints to other developing countries to improve student math learning in basic education.

This dissertation also contributes to the literature on evidence use in development aid for education through a case study of an organization that actively utilized evidence to improve educational aid. While it depends upon development agencies to utilize evidence to improve strategy and practice, the literature mainly supposes one-way communication from researchers to development agencies, rather than an interactive process between the two entities. It does not focus on organizational aspects such as the initiatives and management of development agencies. A prominent example of an

organization that utilized evidence to improve operations in educational aid is the Indian NGO "Pratham." Since the early 2000s, Pratham has conducted a series of rigorous evaluations in collaboration with researchers. As the case of evidence use by Pratham is longitudinal and includes several examples of impact evaluation, it describes how the organization actively utilized evidence to improve operations.

This dissertation is composed of five chapters. The second and third chapters present the results of a RCT in El Salvador. The second chapter focuses on the impact of the package of interventions on student math learning in primary education, and the third chapter demonstrates the results of the analysis at the lower secondary level of education. The fourth chapter estimates the impact of the package of interventions on student math learning in Niger. The fifth chapter explores the external validities of evidence from El Salvador and Niger, using the method of "mechanism mapping." The sixth chapter is on the case study of evidence use by the Indian NGO "Pratham," and draws lessons for other development agencies on evidence use.

Chapter 2 evaluates the effectiveness of a package of interventions, including the distribution of textbooks that are carefully designed to improve math learning, using data collected in the RCT in El Salvador. To capture the progress in learning over two years, the chapter linked math test scores at the end of the primary 2nd grade and the 3rd grade, using the item response theory (IRT). The average one-year impact of the package on math learning is estimated 0.49 standard deviations of the IRT scores. The average accumulated impact of the first-year interventions in the following year is 0.13 standard deviations of the IRT scores. The package of interventions improved math learning, and the impact persisted even after schools in the control group also received the package of interventions in the following year.

The Ministry of Education of El Salvador scaled up the package of interventions nationwide for grades 7 through 9 (the lower secondary education level), but the ministry could not cover several parts of the program, including the distribution of student math workbook and diagnostic math test, because of budget constraints. Chapter 3 investigates the impact of the components, which were not

covered by the Ministry of Education, in a package of interventions on math learning at the lower secondary level in El Salvador. The study also linked test scores at different rounds of the survey by the item response theory (IRT). In year 1 of the research, the additional components had a positive impact for students with lower household economic status, and the average impact is estimated at 0.17 standard deviations. However, the impact did not persist in the following year. Causal mediation analysis is employed to unpack the causal path on the first-year impact.

Chapter 4 investigates the impact of a package of interventions that included training for SMCs and the distribution of math workbooks on math learning in Niger. The package was scaled up by the ministry of education for approximately 310,000 students in the 1st to 4th grades in approximately 3,500 public primary schools. The scaled-up interventions aimed to help the students improve their math learning through extra-curricular remedial activities that they participated in over a three-month period. Due to budget constraints, the distribution of math workbooks was limited to students from the 1st to 4th grades among the six grades in primary education. Focusing on the difference in the intervention between the 4th and 5th grade students, the study investigates the impact of the package of interventions on student math learning using three-round survey data. The study finds that the average impact of the interventions on math learning outcomes is estimated to be 0.36 to 0.38 standard deviations. The impact is larger for students with lower baseline scores.

Chapter 5 explores the applicability of the packages of interventions in El Salvador and Niger to other low- or lower-middle-income countries, using the analysis framework called “mechanism mapping” proposed by Williams (2020). The mapping exercise clarifies the important contextual assumptions to be reviewed when applied for other contexts. For example, the development of math textbooks depends on the contextual assumptions from the institutional aspect such as math curricula, cultural aspect such as mother tongue and instructional language, and organizational aspect such as the capacity for printing/procuring and delivering textbooks for schools. The fifth chapter discusses the applicability of the packages of interventions developed in El Salvador and Niger to other countries, and possible measures to enhance external validities.

Chapter 5 also presents a case study of evidence use by the Indian NGO “Pratham” in the appendix. In a series of impact evaluations, Pratham identified the research agenda that addressed the gap between the mission and actual level of performance of the organization. Since the research agenda originated from the strategic concerns of Pratham, the results of the experiments were highly relevant to the strategy and operations of the organization. The leading management in Pratham played a central role in promoting and coordinating the experiments. With the active involvement of the leading management, impact evaluations were embedded within the operational and decision-making structure of development agencies, by which evidence was fed back well into the strategy and operations of the organization. Based on an equal partnership between Pratham and researchers, knowledge and expertise were exchanged in the process of experiments effectively, which made the evaluations productive. The lessons from the case study of Pratham provide insights for bilateral or multilateral development agencies to utilize evidence to improve and expand their operations in education aid.