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OPEN SOURCE SOFTWARE IN SCHOOL MATHEMATICS EDUCATION: OPPORTUNITIES AND CHALLENGES

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ABSTRACT:

Schools in many countries, including India, want to use technology in mathematics teaching but face limited budgets and unequal access. Open source software (OSS), which can be used, studied, changed and shared freely, is often suggested as a practical answer. The purpose of this study is to examine the opportunities and challenges of using OSS in school mathematics education, with special reference to India. A narrative review was carried out using peer-reviewed studies, meta-analyses, official platform documents and national policy and survey reports. The findings were grouped into themes through simple content analysis. Four opportunities were identified: free access and lower licence cost, freedom to adapt and localise, evidence of learning gains, and support for conceptual understanding and computational thinking. Five challenges were also identified: hidden costs and unequal access to devices, limited teacher training, uneven support and learning resources, sustainability and licence issues, and gaps in evidence from Indian classrooms. Studies on GeoGebra, the best-researched open-source mathematics tool, report mostly positive effects on achievement, but the effects depend on class size, access to computers, task design and teacher preparation. India's DIKSHA platform shows that open source can also work at national scale. The study concludes that OSS lowers the cost of software but not the cost of good teaching. Teacher training, devices, local-language resources and community support must be developed together. More classroom studies from Indian government schools are needed.

KEYWORDS:

OPENSOURCE SOFTWARE, SCHOOL MATHEMATICS, GEOGEBRA, DIKSHA, TEACHER PREPARATION.

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1. INTRODUCTION

Most schools want to use technology in mathematics teaching, but many cannot afford expensive software. Licence fees, yearly renewals and dependence on one company are serious problems for government and low-fee schools. Open source software (OSS) offers a different path. It is software whose licence allows users to use it freely, study its source code, change it and share it with others (Open Source Initiative, n.d.). In school mathematics, well-known examples include GeoGebra for geometry, algebra and calculus, Python and Scilab for computation and programming, and Moodle for online courses.

India has already adopted OSS at national level. The Digital Infrastructure for Knowledge Sharing (DIKSHA), the national platform for school education, is built on Sunbird, an open source technology under the MIT licence, and each State or Union Territory can use it in its own way (National Council of Educational Research and Training [NCERT], Central Institute of Educational Technology [CIET], n.d.). The National Education Policy 2020 also supports the wider use of technology in teaching, learning and assessment (Ministry of Education, 2020).

Previous research on OSS in mathematics is mainly about one tool, GeoGebra. Meta-analysis and experimental studies report positive effects on student achievement (Juandi et al., 2021; Zulnaidi& Zamri, 2017; Zulnaidi et al., 2020), and an early study of teacher workshops described the difficulties teachers face when they first learn the software (Hohenwarter et al., 2009). Though, few studies examine OSS in its whole, including its advantages in terms of cost, flexibility, and community as well as possible risks for educational institutions. This paper therefore aims (a) to describe the main opportunities of OSS in school mathematics, (b) to examine the key challenges, and (c) to

suggest a way forward for Indian schools.

2. MATERIALS AND METHODS

This study follows a narrative review design. Peer-reviewed journal articles, a meta-analysis, official platform documents, and national policy and survey reports on open source tools in school mathematics were identified through web and journal database searches. Sources were selected for relevance to school-level mathematics, credibility and focus on opportunities or challenges. As most of the literature is based on GeoGebra, hence, for this review, GeoGebra is used as the main example, while DIKSHA is used as an Indian example. The results have been categorized under two themes namely opportunities and challenges through simple content analysis. As the research is based on the available literature, hence, no data have been collected through field survey.

3. RESULTS AND DISCUSSION

3.1 MAJOR OPPORTUNITIES

3.1.1 FREE ACCESS AND LOWER LICENCE COST

The first and most obvious benefit is that OSS can be downloaded, installed on school computers and shared with students without licence fees. A school can therefore equip an entire computer laboratory with the same mathematical tools, and students can use them at home as well. This removes one important barrier, although, it does not remove the cost of hardware, internet and training.

3.1.2 FREEDOM TO ADAPT AND LOCALISE

Open licences allow software to be translated, modified and combined with local content. This is valuable in a multilingual country like India, where students learn mathematics in many languages. DIKSHA shows the idea at scale: it is built on an open source base and States can use its capabilities to design their own programmes for teachers, learners and administrators (NCERT & CIET, n.d.). Teachers also gain freedom, because tools such as GeoGebra allow them to create their own interactive materials and are not limited to fixed commercial content.

3.1.3 EVIDENCE OF LEARNING GAINS

GeoGebra is the best-researched open source tool in school mathematics. A meta-analysis of 29 studies reported a large average effect on students' mathematical ability, and found that the software worked better in groups of 30 or fewer students, where each student could use a computer, and in shorter treatments of up to four weeks (Juandi et al., 2021). In a quasi-experiment, students taught using GeoGebra showed higher conceptual and procedural knowledge and better achievement than students taught by conventional methods (Zulnaidi& Zamri, 2017). A later quasi-experiment found higher achievement in functions and limits, and also reported that teachers and students accepted the software, although it was time consuming to use (Zulnaidi et al., 2020). These studies are encouraging, but they are mostly small and short, so the large effect sizes should be read with care.

3.1.4 SUPPORT FOR UNDERSTANDING AND COMPUTATIONAL THINKING

Dynamic tools let students drag a point or change a value and see the result at once, which helps them to notice patterns and make conjectures. Open programming tools such as Python or Scilab allow students to model and calculate, which fits with the emphasis of the National Education Policy 2020 on computational and mathematical thinking (Ministry of Education, 2020).

3.2 MAJOR CHALLENGES

3.2.1 HIDDEN COSTS AND UNEQUAL ACCESS

Free software does not mean free to use. Schools still require computers, electricity, and internet access. According to Juandi et al. (2021), there was an improvement in the outcomes when students had personal computers; however, this is not available in most government schools. At home, even if one has a smartphone, it does not mean the use will be educational because the device can be shared and may lack data and instructions (ASER Centre, 2025).

3.2.2 LIMITED TEACHER TRAINING

Teachers need time and support to learn new tools. A study of professional development with GeoGebra identified common difficulties faced by teachers in workshops and rated the difficulty of different tools, which later helped to improve training materials (Hohenwarter et al., 2009). Teachers' beliefs about teaching also matter: those with teacher-centred beliefs tend to use technology only for presentation (Ertmer et al., 2012). Without regular training, OSS may be installed but not used meaningfully.

3.2.3 UNEVEN SUPPORT AND LEARNING RESOURCES

OSS depends on community help, such as forums, shared materials and volunteer translators. This help can be excellent, but it is not always available in regional languages or matched with the syllabus of every State board. Teachers in remote schools may find it hard to get quick technical help, and may need ready-to-use, curriculum-linked lesson resources.

3.2.4 SUSTAINABILITY AND LICENCE ISSUES

Open source projects need continuing funding, developers and users. Licence terms, ownership and business models of projects may also change over time. Schools and education departments should therefore read licence terms carefully, prefer tools with active communities and keep their own copies of important teaching materials.

3.2.5 GAPS IN EVIDENCE AND RISK OF TOOL-CENTRED TEACHING

Most studies come from other countries, and relatively few are from Indian government schools. Evidence also shows that digital tools work only when tasks, teachers and context are well designed (Drijvers, 2015; Hillmayr et al., 2020). A powerful free tool used only to display a textbook solution will not improve learning.

4. DISCUSSION

4.1 WAY FORWARD

The literature suggests that OSS reduces the cost of software, but not the cost of good teaching. Four actions can help. First, education departments should provide basic devices and connectivity, so that free software can actually be used, preferably with one device for each student or pair in practical lessons. Second, pre-service and in-service teacher education should include practical training in open-source mathematics tools. Professional development should extend beyond software operation to lesson design, formative assessment, mathematical discussion and the interpretation of students' reasoning (Thurm et al., 2024).Third, there should be the development of regional language lessons and GeoGebra activities based on the curriculum in line with the national policy, through platforms such as DIKSHA. Fourth, schools should select tools with licenses and active user community while planning for future sustainability. Policymakers should prioritize schools that have less resources in order to support equity through open source software, as intended by the national policy (Ministry of Education, 2020).

4.2 CONCLUSION

Open source software gives schools free access, freedom to adapt and a growing body of evidence of learning gains in maths. Its success is conditional on devices, trained teachers, local language resources and sustainable communities. If all of these are developed in parallel and the tasks are designed to encourage exploration and reasoning then open source tools can make high quality maths learning both more affordable and more inclusive.

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