A data analysis plan for an independent analysis of product usage and its link to student attainment, based on data collected from students in years 7 and 8 in schools using Sparx Maths

Elena Rosa Brown & Andreas Culora, RAND Europe

Sonia Ilie, University of Cambridge

Version 0.1
As of May 20th, 2020

RAND EUROPE

UNIVERSITY OF CAMBRIDGE

Background

Educational technology (hereafter Edtech) is undergoing a period of unprecedented growth, particularly in the UK,[1] with schools increasingly looking to Edtech to support teaching and learning in the classroom. Schools in the UK spend £900 million on Edtech every year, while the global market is currently estimated to be worth over £100 billion.[2] The UK has more than 1,200 Edtech companies offering products and services[3] to meet the needs of schools, students, and parents. Alongside this growth, there is a developing body of evidence to support the beneficial role of Edtech across different age groups and for most areas of the curriculum.[4] In fact, Edtech is seen as a crucial part of modern curriculums, with agencies such as the Department for Education creating policies to support the use of Edtech in schools.[5]

Sparx Maths[6] – a personalised, technology-based approach to teaching and learning maths in Secondary schools – is currently being used in a number of schools across the UK following many years of active research in schools.[7] This study explores the effectiveness of Sparx Maths, including how its use relates to pupil outcomes. This document outlines the analytical approach to be applied to existing Sparx Maths usage and pupil achievement data in order to achieve the aims of this study.

Research Questions

Primary research question:

RQ1: What is the relationship between usage of Sparx Maths and pupil achievement in maths for Year 7 and Year 8 pupils in the UK?

Further research questions:

RQ2*:* To what extent is time spent on Sparx Maths associated to pupil achievement in maths?

RQ3: To what extent is Sparx Maths associated to pupil achievement in maths differently, depending on their demographic and/or socio-economic characteristics?

Methodology

Developing a Theory of Change

This study is a collaborative endeavour, starting with work with Sparx to outline how Sparx Maths works in practice to impact on pupil outcomes, including how some factors (e.g. total question time on homework, product type, proportion of FSM on roll) may act as mediators or moderators. This was collected in the form of a Theory of Change (see Appendix 1). This was used to generate research the research questions which in turn inform this data analysis plan.

Ensuring independence

In keeping with best practice in statistical analysis, this data analysis plan outlines in detail the research questions we will answer and the statistical approaches that we will use to analyse the data. By working in this way, we strengthen the robustness of the methodology and findings by protecting against allegations of 'data dredging' (i.e. the misuse of data mining techniques to find significant results).

---

[1] https://www.jisc.ac.uk/rd/projects/edtech-launchpad
[2] https://www.tandfonline.com/doi/full/10.1080/23265507.2017.1365623?af=R
[3] https://edtechnology.co.uk/Article/the-uk-ranks-1-in-edtech-venture-capital-funding-in-europe/
[4] https://educationendowmentfoundation.org.uk/evidence-summaries/teaching-learning-toolkit/digital-technology/#security
[5] https://www.gov.uk/government/news/edtech-strategy-marks-new-era-for-schools
[6] https://sparx.co.uk/
[7] https://sparx.co.uk/wp-content/uploads/2019/06/Why-Sparx-Maths-works.pdf

Data

Sparx routinely collects data on usage of Sparx Maths and also currently holds achievement records for pupils who have used Sparx Maths. At the pupil-level, data include: background characteristics; maths achievement captured with a standardised test (PUMA); prior attainment collected from school records; usage records in relation to Sparx Maths, with some pupils not using Sparx Maths at all (akin to a comparison group). At the school level (and in some instances at class level), data include a range of background characteristics (averages per schools), for example, proportion of pupils eligible for free school meals (FSM), proportion of pupils with English as an additional language (EAL). All relevant data will be used in the analysis, as outlined below.

Sample

The above data has been collected from a set of 14 UK schools who routinely use Sparx Maths for year 7 and/or year 8 pupils. 3,956 pupils in Year 7 and Year 8 took part, including some who were in cohorts that did not use Sparx Maths at all (mostly year 8), and some who had used it for varying lengths of time between a few months and two years.

Analysis

The overall analytical approach accounts for the nested nature of data, with pupils in classes in schools. Multi-level (or random effects) models will therefore be used to estimate linear regression models that respond to the research questions above and explore the relationship between Sparx usage and achievement in maths while controlling for background characteristics of pupils, classes, and schools. All analyses will be conducted in Stata version 15 and onwards.

Primary outcome analysis

In response to the primary research question (RQ1), a multi-level (random effects) model will be estimated, with: the outcome variable will be maths achievement (standardised scores on Hodder PUMA tests); key stage 2 scores will be used to control for prior attainment; control variables at the pupil level will include all socio-demographic data including gender, FSM eligibility, EAL status, etc., as above. As a robustness check, the PUMA scores will be substituted with (1) the PUMA age-corrected score; and (2) predicted GCSE scores which have been previously derived from a combination of the corrected PUMA score and prior distributions of GCSE scores. These robustness analyses serve to establish the robustness of the final estimate of the relationship between Sparx Maths participation and maths achievement to different ways of capturing maths achievement.

Missing data

In line with best practice, we will specify the number of complete cases (i.e. those without any data missing) and attempt to establish the missingness mechanism (i.e. if, and how variables in the data are predictive of non-response). We will use logistic regression models first, to understand if missingness is associated with any other student characteristics; and to start understanding the pattern of missing data. Depending on the observed pattern of missing data, we will then explore the possibility of imputing missing data or instead use a missing data indicator when estimating models. This applies to control and predictor variables; we will not carry out any imputation of the outcome measure. Separately, as a robustness check we will also run the models in a full information maximum likelihood approach (FIML). Instead of replacing values through imputation, FIML handles the missing data in each respective final analysis model and provides unbiased results.

Additional analyses

To explore how different aspects of Sparx Maths usage relates to the main maths outcome, and to respond to RQ2, a series of multi-level models will also be estimated. These follow the approach for the primary outcome analysis to use key stage 2 scores as a measure of prior attainment, and will build in complexity in the following order:

1) The total working time in the classroom;
2) The total working time on homework;
3) And a measure of overall usage composed of the total Sparx Maths working time across both classroom and homework settings.

Subgroup analyses

Additional analyses will be conducted looking at the impact of Sparx Maths on different students (RQ3). The main model in the primary outcome analysis will be re-specified to respectively include interaction terms that will be able to isolate the specific association between Sparx Maths and pupil maths outcomes for the following groups: pupils with EAL; pupils eligible for FSM (or Pupil Premium, PP, if reported in that manner by each school). Each of these groups will be captured by a binary indicator, to be interacted in each model with the binary variable that captures participation in Sparx Maths.

To understand the relationship between Sparx Maths and maths achievement for pupils with lower prior attainment, the distribution of key stage 2 data will be used to generate a binary variable identifying pupils in the bottom 25% of the prior attaining distribution. This variable will then be interacted with the Sparx Maths participation dummy as for the other sub-group analyses above.

Exploratory analyses

Propensity score matching (PSM)

We will explore the possibility of establishing a stronger (though not perfect) counterfactual by using propensity score matching (PSM). This approach uses data from a non-random-allocation research design (as is the case here) to estimate effects of treatment (in this case participation in Sparx Maths) on outcomes[8] by using available data to produce quantifiably similar pairs of pupils who differ only in their use of Sparx Maths (i.e. one pupil in the pair will have used Sparx Maths and the other will have not). This will be explored and results of both the process and the outcome will be included in the final report.

[8] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3144483/

Appendix 1

Theory of Change Diagram

OVERALL IMPACT:	Student's attainment in mathematics is improved.			
INPUTS	**OUTPUTS**		**OUTCOMES**	
Resources	Activities	Outputs	Short-term outcomes	Long-term outcomes
What do you need to make Sparx Maths happen?	***What do you do to make the Sparx Maths happen?***	***What happens as a result of Sparx Maths?***	***What are the first changes that occur as a result of Sparx Maths?***	***What is the eventual impact that occurs as a result of Sparx Maths?***
Homework Product School designates Sparx Leader (usually a senior teacher or HoD) and arranges training sessions for all of the Maths Department as part of the onboarding process. Schools provide the teachers access to the internet and a suitable device somewhere in the school. Each child has access to the internet and a suitable device at home or can be provided with this by the school in a homework club setting. **+Classroom Product** All students in the class and the class teacher need access to an internet connected device and all classrooms where maths is taught need internet access.	Sparx leader and HoD make key implementation decisions. In particular, which scheme of learning to use (pre-built or customized). All maths teachers are trained. All students are enrolled. Maths homework is set weekly using Sparx Maths (this will happen automatically, but teachers can adjust the topics to match what they have been teaching if they have diverged slightly from the scheme of learning). For the classroom product teachers deliver lessons through Sparx Maths. Teachers monitor homework and classroom insights and adjust their teaching appropriately, based on the data and insights that Sparx provides. Sparx monitors implementation via weekly homework and lesson completion rates and will intervene proactively if required. Sparx leader has a regular termly catchup with Sparx to iron out any problems and promote best practice.	Every student receives regular personalized homework assignments consisting of appropriately challenging questions on in focus topics as well as consolidation and revision questions picked using a spaced repetition algorithm and delivered in an interleaved order. Students are given instant feedback. When students attempt a question, they must get it right before it is classed as completed. Following an incorrect answer, the numbers in a question will be changed. Students can get help at any time by accessing one of the support videos. Teachers receive regular insights based on lessons and homework about the performance of individual students and whole classes, pinpointing weaknesses so that they can be addressed directly. Work is automatically set and marked, and lesson plans help with medium and short term planning.	Homework completion rates improve dramatically. Nearly all (>85%) of students will complete all their compulsorily assigned questions. In addition, a significant percentage of students elect to do some optional or target questions in homework. Students start to spend time working on high quality maths content that is calibrated to their ability level. (In their zone of proximal development). Where they find questions are too difficult they can use support videos to help them master the skills. Student misconceptions are reduced. Teachers start to use insights to target their teaching either at topics the whole class found difficult or at individual students who the system flagged as struggling. Teachers are able to spend a larger percentage of their time teaching rather than marking or setting tasks.	Students' maths progress is faster than it would have been without Sparx Maths. This is most striking for the lower ability students, eventually leading to higher attainment at GCSE than would otherwise have been expected. Student motivation and engagement is improved. Students become more confident that they "can do maths" Teacher non-teaching workload is greatly reduced.

EXTRENAL FACTORS (context)

The main factor here is level of school funding and funding for IT, which affects school's willingness to take on Sparx Maths.

INTERNAL FACTORS (moderators)

Poor wifi coverage and/or an insufficient number of devices will reduce the impact of Sparx maths.

Demographic factors concerning the intake of pupils (KS2 scores, Percentage of PP/EAL students) may affect outcomes.

As with all interventions it is important that teachers 'buy in' to using Sparx this is more important for the classroom product as the homework product is highly automated.

Schools homework enforcement policies can also potentially affect outcomes. Sparx gives schools the tools to easily enforce a strict policy on homework completion. We believe this is necessary for maximum effectiveness, but in the end it is up to the School how they use these tools.