Context and Implications Document for:
Inquiry-based learning put to the test:
Medium-term effects of a science and technology for children programme

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Authors’ Introduction

In many countries the interest in, and recruitment to, science and technology education is regarded as insufficient relative to the needs arising from rapid technological change and global challenges, e.g. with respect to the environment and the supply of food. One approach that has been suggested to remedy these problems is to substitute inquiry-based learning (IBL) for traditional teaching methods. That means replacing teacher lectures based on textbooks by hands-on, experiment-based learning, where the students actively search for knowledge, with the teacher acting as a guide. The Science and Technology for Children (STC) programme is an example of IBL, characterised by science kits—experiment boxes—and extensive teacher support programme—manuals, documentation and competence development. While the STC programme has many advocates, it is certainly not embraced by all. Critics argue that IBL will only work in situations where the students have a good knowledge of basic science facts and methods beforehand. Research overviews also show that the jury is still out on IBL versus traditional teaching methods. More empirical analyses are needed to determine if IBL is efficient and, if so, under what circumstances. This study contributes by showing how large-scale, up-to-date, quantitative evaluations can be carried out in the common situation when participation in IBL has not been assigned by means of a randomised controlled trial. For policy-makers, the important message is that the implementation and widespread, preferably nationwide, use of standardised tests is essential for reliable evaluations of the effects of teacher support programmes. For science teachers, a noteworthy finding is that the effects of the STC programme vary across subjects and appear to be larger for subjects in which the teacher’s and/or students’ knowledge is relatively
less comprehensive, indicating that the programme may be used as a compensatory
device.

**Implications for Practice**

The evaluation shows that the STC programme has had a positive and statistically significant effect (effect size 0.24) on the skills in physics among Swedish grade 9 students, which predominantly participated in the STC programme during grades 4–6. In establishing this result, we draw three conclusions of practical importance:

(1) When participation in the STC programme is not randomly assigned, it is of paramount importance to account for the fact that participants may differ systematically from non-participants. In our case, ignoring this issue, results in significantly negative effects of the Swedish STC programme.

(2) The effects of the STC programme may differ across subjects. In our case, no significant effects are found with respect to biology and chemistry. Such heterogeneity may be due to differences with respect to initial skills across subjects, on the part of students or on the part of the teachers. It may also depend on the balance chosen in teaching, between, on the one hand, generic principles of instruction and, on the other hand, subject matter.

(3) The choice of outcome measures may matter a lot for the results. In our case, using national standardised test results yields positively significant results, while the use of grades does not yield any significant results at all.

**Resources for Teaching & Learning in Higher Education**

*Author Recommends*

For a discussion of the need to increase the interest in, and recruitment to, science and technology education, see the *Vision for science and mathematics education* published by the Royal Society (2014). Different theories and modes of learning and their appropriateness in specific circumstances are discussed by James (2006) and Kalyuga et al. (2001). For overviews of the effects of various approaches to science education, cf. Minner et al. (2010) and Slavin et al. (2014).

With respect to the three Implications for Practice noted above the following references are helpful. Guo and Fraser (2010) describe the method making it possible to evaluate the effects educational programmes when the participating students have not been randomly assigned to them. A whole issue of the *Journal of Curriculum Studies* (2004) is devoted to the trade-off in teaching between generic principles of instruction and subject matter that might give rise to different effects of inquiry-based learning across subjects. The importance of using standardised tests as outcome measures, in effect evaluations, is discussed in Geier et al. (2008).
References


Useful Links

https://royalsociety.org/topics-policy/projects/vision/

www.carolinacurriculum.com/stc/

www.ntaskolutveckling.se/In-English/

www.sempcoinc.com/scandteforch.html

www.si.edu/kids

Focus Questions

(1) Why, and when, could inquiry-based learning be superior to traditional teaching methods?

(2) When will disregarding non-random entry into an educational programme overestimate the programme’s effects?

(3) When will disregarding non-random entry into an educational programme under-estimate the programme’s effects?

(4) Reasons why teachers, and students, may have greater need for a support programme like Science and Technology for Children in some science subjects, compared to others? Implications for estimated programme effects?

(5) From an evaluation point of view, what is the main advantage of using national, standardised tests as outcome variables, as opposed to local tests?

Seminar/Project Idea

*Building airplanes out of pizza cardboard boxes in grade 5*

According to the Swedish curriculum for technology education in grade 5 (age 11), the children should learn to build stable constructions, like houses and bridges.
However, those examples do not tend to stimulate the children’s imagination and engagement. To get the children more motivated, one of the authors (Joakim Svärdh) has in his teaching instead chosen airplanes as examples of stable constructions. To show that this alternative can be implemented at a low cost, pizza cardboard boxes, at a unit cost of £0.3, are used as material for the planes’ bodies and wings. Engines are bought via the internet from Hong Kong at £10 each and can be recycled for subsequent projects.

The learning process is made up of theoretical lectures provided by the teacher, hands-on exercises and experiments. The practical elements are performed by groups or pairs of children.

In terms of subject matter, the focus is on technology education (material characteristics and construction principles), and physics (mass point determination, principles of flying/gliding and electronics). In addition, the project trains process skills, such as interpreting drawings, cutting and joining. The history of technology and environmental aspects are also touched upon.

To get a progression in the children’s learning, the grade 5 project is preceded by the folding of paper planes in grade 4 and followed by the building of radio-controlled drones in grade 6.

This project is much appreciated by the children; they have fun and learn a lot, both with respect to plane construction and about working together. From the teacher’s perspective the facts that no part of the work is conducted by individual pupils and no individual-level test is conducted pose interesting challenges with respect to assessment.