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What Works in Education?

Using Evidence to Improve Education

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Does student learning improve through project-based instruction?

Marc Lafuente Martínez

In recent years, project-based learning (PBL) has gained popularity under the umbrella or international organizations, governments and schools that view this methodology as a tool to improve student learning and promote the skills of the 21st century through the exploration, creation and the construction of solutions to problems. Meanwhile, studies have begun on the effects of this education, revealing their possibilities and real limitations. This review formulates the following questions: what impact do project-based instruction and centres of interest have on student learning? What are the characteristics of the most effective programs? For whom are these programs most effective? Should this educational practice be expanded in Catalonia?

"For too long, education has been subject to inertia and based on traditions, and educational changes have been grounded in unfounded intuitions and beliefs. The 'What Works' movement irrupts into the world of education with a clear objective: to promote evidence based policies and practices. Ivàlua and the Jaume Bofill Foundation have come together to push this movement forward in Catalonia."

What Works in Education?

Using Evidence to Improve Education

Does student learning improve through project-based instruction?

Marc Lafuente Martínez
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Motivation

There is currently a decisive interest in educational innovation as an instrument for improving student learning. Methodologies such as project-based learning (PBL) are gaining in popularity [1] as tools to promote the skills of the 21st century through the exploration, creation and the construction of solutions to problems.

International organizations like the OECD have indicated that PBL and other methodologies based on experiential learning may help to improve student learning, placing students at the centre of the educational experience and comparing it to the situation studied [2]. Similarly, many schools in Catalonia are transforming their organization and operations to implement approaches such as PBL. The Government of Catalonia's Ministry of Education is contributing to this transformation, valuing educational innovation as "an instrument of systemic transformation and structural improvement of the educational system" [3]. The ministry reports that "flexibility is required in curricular management and organization to enable different learning strategies [...] like group work, experimentation, project-based instruction and others".

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Both at home and abroad, educational innovation arises as an attempt to promote certain skills that seem difficult to produce with methodologies in which students maintain a passive attitude while learning [4]. PBL is considered a form of learning that encourages students to assume more responsibility for their learning, promoting the search and analysis of information and solving real problems, while delving deep in content linked to their personal interest. Therefore, at first glance this methodology seems better suited to fostering skills such as critical thinking, creativity, learning how to learn, complex problem solving, etc. As such, PBL is presented as an opportunity to improve students' learning outcomes, especially in their skill set. A need for improvement in the acquisition of certain skills has been detected in Catalonia: the skills assessment led by the Catalan Ministry of Education shows a general stagnation in the results in primary school [5]. Improvement is seen in secondary school, with lower scores in mathematics (68.2) and scientific and technological skills (66.2) than in language skills (76.7 on average) [6].

PBL is presented as an opportunity to improve students' learning outcomes, especially in their skill set.

In recent years, studies have begun to be carried out, especially international ones, which can give us insight into the possibilities and real limitations of project-based instruction for improving our students' learning.

What programs are we talking about?

This review focuses on project-based learning (PBL). Currently, there is a conglomerate of similar terms that makes it difficult to establish clear boundaries between this approach to learning and others [7], such as problem-based learning, inquiry-based learning, discovery-based learning and more. Beyond the labels, this review will assume that the learning experience must be defined by the development of a project. This is due to compliance with the following principles [1] [8]:

Beyond the labels, this review will assume that the learning experience must be defined by the development of a project.

- Raising a question or issue linked to some authentic phenomenon or one pertaining to the situation that will guide the project.
- Cooperative development by students of a series of usually complex tasks with a high level of autonomy and decision-making, taking an active role in order to solve the initial question (this implies dedicating a considerable time to the project, more than one class session).
- The creation of one or various products or devices resulting from attempts to respond to the initial question and the students' reflection.

- The publication or presentation of this product to certain people.
- Raising learning objectives linked to the development of the project.

Condliffe *et al.* [8] have distinguished three models for implementing PBL in schools:

1. **Application of an externally designed PBL curriculum:** teachers implement a series of curricular units in the classroom that are designed by organizations or programs outside the school. These programs provide designed content and activities along with methodological materials and instructions.
2. **PBL begun by the teachers:** the teachers design and implement their own PBL, doing their own programming in which they can use resources that they find along the way or that are inspired by principles of other works. This is probably the most widespread model.
3. **PBL as a school-wide practice:** PBL is part of the school's educational project and is therefore implemented in most classrooms. The school often forms part of a broader network of educational centres like Expeditionary Learning Education in the United States, for example (Box 1), which provides resources and training for all teachers. These networks promote global cultural changes in the school, of which PBL is only one part. It seems that this is a rising model with regard to its use.

The programs can also be distinguished according to whether they are:

1. **Unidisciplinary:** the program is applied to a single curricular area.
2. **Multidisciplinary:** the program is applied to more than one curricular area, whether in a more or less coordinated manner.

Box 1.

An example of PBL: Expeditionary Learning Education

Expeditionary Learning (EL) Education began in 1991 from a partnership between the Harvard faculty of education and Outward Bound. EL currently consists of a network of 15 kindergarten, primary and secondary schools in the United States that promote PBL based on creating a community of educators who share resources. Above all, PBL concentrates on projects in the area of languages and the arts.

EL is based on developing projects where students conduct research outside school in the form of day trips or expeditions. The projects can take different learning formats: lessons in the classroom, discussions, practices in laboratories, seminars, research and fieldwork. These projects are created in collaboration with others and put reflective processes into practice through the analysis of real-world phenomena. Students produce a portfolio during the program and develop a product in the end that reflects their learning. For example, students may develop a project where they have to interview and meet individuals from a particular nearby community, followed by creating murals representing the biographies of these people.

In addition to PBL, other approaches like service learning and place-based learning are used. Thus, students are encouraged to:

- acquire knowledge and skills from a particular discipline;
- develop personal and social skills like initiative, perserverance, responsibility and collaboration;
- create authentic work and products that put complex skills in play.

The EL adopts a model of global change at the school based on its cultural exchange. General changes in curriculum, school organization, instruction and learning assessments are promoted. The school receives the support and training from university academics. Teacher training is developed through coaching sessions, face-to-face seminars, classroom observation and feedback, virtual learning communities, the provision of curricular materials, virtual courses and expert webinars.

For further information: <https://www.eleducation.org>

Questions influencing the review

This review raises four questions:

1. **What impact does work on projects and centres of interest have on student learning?**
   We analyze the impact between PBL and students' academic performance, the affective and motivational aspects involved in learning and crosscutting skills like critical thinking, creativity and digital competence.
2. **What are the characteristics of the most effective programs for project-based instruction?**
   We analyze the results of PBL according to the curricular area, the intensity and the duration of the program, as well as the use of digital technology.
3. **For whom are project-based instruction programs most effective?**
   We analyze the results of PBL based on the students' level of education and profile.
4. **Should this educational practice be expanded in Catalonia? Which conditions should be met?**
   We consider whether it might be appropriate to implement PBL in Catalonia, focusing on the success factors that come with these kinds of programs.

Reviewing the evidence

In order to answer the previous questions, we have searched for reviews or meta-studies that have systematically addressed the effectiveness of PBL in the learning of school-age children (kindergarten, primary and secondary school). In total, eight quality reviews were identified, one of which is a quantitative meta-analysis and the seven remaining of which are narrative reviews (Table 1). All conclusions of the success factors of the programs covered by the seven narrative reviews have been noted and we have observed that these reviews include little causal evidence about the impact of learning, but this has been made clear and noted in the table.

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Table 1.
Main results of the review of the identified reviews of PBL

Reference	Number of studies included in the period	Students/context	Curricular areas	Summary of the effects* and key factors
Meta-analysis				
Chen & Yang (2019) [1]	30 (1998-2017)	Primary and secondary schools and centres of higher education. Nine different countries.	Social sciences, natural sciences and mathematics, technology and engineering.	• **Academic performance: d = 0.71** • Programs in the **social sciences and languages (d=1.05)** are statistically higher than those of science and mathematics (d=0.64). Also positive results for technology and engineering (d=0.81), but not higher than those of science and mathematics. • Programs **of over two hours per week (d = 0.76)** are statistically higher than those that invest two hours or less per week (d = 0.35). • Programs **with technology (d = 0.74)** are statistically higher than those that do not use technology (d=0.61). • Programs in **primary (d = 0.73) and secondary schools (d = 0.68)** with similar effectiveness..
Narrative reviews				
Benett *et al.* (2018) [9]	39 (2000-2015)	Secondary and post-compulsory education, schools and non-formal education. USA and United Kingdom.	Natural sciences.	• Key factors (teachers): regulate the amount of time spent, overcome lack of self-confidence, curricular integration, external inspections consistent with the objectives of PBL.
Condliffe *et al.* (2017) [8]	71 (2000-2017)	Primary and secondary school. Especially USA.	Natural sciences, mathematics, social sciences and arts/ language.	• Better integration of conceptual and procedural knowledge. • **Better performance in economic knowledge (d = 0.32) and economic problem solving (d = 0.27).** • Better performance in foreign language vocabulary (English). • Better understanding of content and transfer of knowledge after nine weeks. • Key factors: initial and continued teacher training, instructional consistency, teacher coordination and institutional support, an initial level of sufficient students.
Kokotsaki *et al.* (2016) [10]	35 (1998-2015)	Kindergarten, primary and secondary schools and higher education centres. Different areas.	Various.	• Key factors: use of new technologies, qualitative collaborative processes among students, teachers' ability to build learning, balance between direct instruction and research methods, institutional support and school leadership, consistent learning assessment.
Hasni *et al.* (2016) [11]	48 (2000-2014)	Primary and secondary schools and higher education centres. Especially USA and Israel.	Natural sciences and technology.	• Key factors: project management, supervision and effective help in learning, regulation of the use of time, curricular integration and consistency of evaluation, initial skills of students, teacher training.
Holm (2011) [12]	17 (2000-2011)	Kindergarten, primary and secondary schools. Especially USA.	Various.	• Key factors (teachers): manage the classroom, understand the contents well, mark clear objectives, help students in a personalized way, overcome resistance to change. • Key factors (system): address methodological changes at school-wide and across the system.

Reference	Number of studies included in the period	Students/context	Curricular areas	Summary of the effects* and key factors
Narrative reviews				
Legget & Harrington (2019) [13]	8 (2012-2016)	Primary and secondary schools with socio-economically disadvantaged students. Especially USA.	Various.	• Reading and writing: ES = -0.13 (**disadvantaged students: ES = -0.24**) • Involvement: ES = 0.01 • Attendance: ES = -0.08 • Possible positive differences in the students' oral and communicative, collaborative and self-management skills. • Key factors: good support for management and organizational changes.
Thomas (2000) [14]	49 (1989-2000)	Primary and secondary schools. Especially USA.	Various.	• Key factors (teachers): the teaching staff needs training and support; help students to learn how to learn. • Key factors (system): integration in changes that affect the school as a whole.

* In bold, the statistically significant results in CI = 95%. d = standardized mean difference (Cohen estimator). ES = effect size as given by the study. Values around or below 0.2 indicate a small effect; values around 0.5, an average effect; values around or greater than 0.8, a great effect).

Source: Author's creation.

In order to gather more evidence from experimental and quasi-experimental studies with quantitative comparisons with a control group, we conducted a systematic research and review of primary studies. We identified 25 relevant studies: 18 quasi-experimental studies and seven experimental ones, including four research reports of various programs in the United States [15-18]. Table 2 collects the results on the magnitude of the effects and the main conclusions.

We identified 25 relevant studies: 18 quasi-experimental studies and seven experimental ones, including four research reports of various programs in the United States.

Table 2.
Main results of the review of primary studies on PBL

Reference	Type of intervention and dosage	Students/context	Curricular areas	Summary of the effects* and key factors
Experimental designs				
Asan & Haliloglu (2005) [19]	Experience focused on PBL and the use of computers. 8 weeks.	98 students (12-14 years) from a secondary school in Trabzon, Turkey.	Technology.	• **Digital competence: g = 0.03** • Improvement in team work skills.
Duke *et al.* (2017) [15]	PBL experience covering four lessons in social sciences and reading and writing. 12 weeks.	684 students (7-8 years) of low socio-economic states from 20 primary schools in the USA.	Various.	• **Academic performance (social sciences): ES = 0.48** • Reading of informative texts (social sciences): ES = 0.18 • Writing of informative texts (social sciences): ES = -0.04 • Motivation: ES = 0.14 • Key factor: consistency with the initial planning.
What Works Clearinghouse (2013) [18]	Program focused on research projects to develop four areas: socio-emotional, physical, cognitive and linguistic.	364 students from 11 kindergartens in Georgia, Nord Carolina and Tennessee (USA).	Language and mathematics.	• Oral language: ES = 0.06 • Knowledge of the alphabet: ES = -0.03 • Phonological processing: ES = -0.04 • Mathematics: ES = 0.04
What Works Clearinghouse (2009) [17]	Program that provides disadvantaged students with interdisciplinary PBL focused on group instruction, individualized attention and critical thinking. 208 weeks.	394 secondary students from the Seattle area (USA).	Various.	• Drop-out prevention: ES = -0.08 • Completion of the program: ES = 0.05
What Works Clearinghouse (2006) [16]	Program that promotes values related to civility through 24 lessons taught by working with projects, stories and the development of texts. 24 weeks.	400 primary school students from three southern states (USA).	Various.	• **Academic performance (mathematics): ES = 0.46** • **Attendance: ES = 0.48** • Academic performance (reading): ES = 0.31 • Academic performance (civic education): ES = 0.21
Yaman (2014) [20]	PBL experience for learning English. 24 weeks.	43 students of a university prep course in Samsun, Turkey.	Foreign language.	• **Speaking a foreign language: g = 0.84** • **Satisfaction with education g = 3.11**
Yancy (2012) [21]	PBL experience for improving intrinsic motivation and mathematical abilities. 12 weeks.	111 students (12 years) from a rural secondary school in southern Mississippi, USA.	Mathematics.	• **Academic performance mathematics: d = 0.59** • **Greater benefit for boys than girls: d = 0.21** • Intrinsic motivation: d = 0.14

Reference	Type of intervention and dosage	Students/context	Curricular areas	Summary of the effects* and key factors
Quasi-experimental designs				
Baran *et al.* (2018) [22]	Experience based on PBL and the use of games. 5 weeks.	34 secondary school students (14-15 years) in Diyarbakir, Turkey.	Natural sciences (physics).	• **Conceptual content: g = 2.1** • **Satisfaction with the experience: g = 2.57**
Canuteson (2017) [23]	PBL experience and hands-on learning.	76 secondary school students (15-17 years) in Texas, USA.	Mathematics.	• **Academic performance: g = 0.23**
Carter (2016) [24]	PBL-centered experienced in an honors level course. 6 weeks.	122 secondary school students (15-17 years) in New Jersey, USA.	Mathematics.	• **Academic performance: d = 0.96** • Motivation for learning: d = 0.30 • No significant differences by gender d = 0.24
Cervantes *et al.* (2015) [25]	PBL experience and use of authentic scenarios.	461 secondary school students (12-14 years) in Texas, USA.	Various.	• **Academic performance (mathematics): d = 0.64 (7th year students)** • **Reading: d = 0.48 (7th year students)** • Academic performance (mathematics): d = 0.17 (8th year students) • **Reading: d = 0.57 (8th year students)**
Erdogan & Dede (2015) [26]	Experience focused on PBL and the use of computers. 5 weeks.	70 secondary school students (12 years) in Istanbul, Turkey.	Various.	• **Academic performance (science): d = 1.25** • Academic performance (digital technology): d = 0.44
Freer-Alvarez (2016) [27]	Program focused on PBL at different schools with bilingual education. 208 weeks.	248 students from 9 primary schools in Texas (USA).	Various.	• Reading (English): d = -0.14 • Mathematics: d = -0.16 • Mastery of English: d = 0.22 • Key factors: high teacher-student ratios and changes in the leadership of the school district may have negative effects.
Holmes (2012) [28]	Initiative focused on PBL that promotes 21st century skills among disadvantaged students. 6 weeks.	26 primary school students (11-12 years) from the USA.	Various.	• Reading: d = 0.43 • Technological skills: d = 0.79
Ilter (2014) [29]	PBL experience and collaborative learning. 6 weeks.	54 students (10 years) from a primary school in Bayburt, Turkey.	Social sciences.	• **Conceptual knowledge: d = 0.30** • **Motivation for learning: d = 0.39**
Johnson & Cuevas (2016) [30]	PBL experience and research. 8 weeks.	111 students (11-13 years) from a rural secondary school in Georgia, USA.	Language and arts.	• **Perception of critical thinking skills: d = -0.68** • Motivation for reading: d = -0.44
Karpudewan *et al.* (2016) [31]	PBL-based experience on the subject of energy. 2 weeks.	111 students (14 years) from a "selective" secondary school in Kuala Lumpur, Malaysia.	Natural sciences.	• **Knowledge about content: d = 1.70** • **Behavior regarding content: d =- 0.40** • **Attitudes regarding content: d = -0.44** • **Values on content: d = -0.45**

Reference	Type of intervention and dosage	Students/context	Curricular areas	Summary of the effects* and key factors
Quasi-experimental designs				
Kizkapan & Bektas (2017) [32]	Experience focused on PBL. 6 weeks.	38 secondary school students (13-14 years) from Kayseri, Turkey.	Natural sciences (physics).	• Academic performance: d = 0.09
Mudrich (2017) [33]	PBL experience. 8 weeks.	124 students (13-14 year) from a rural secondary school in Alabama, USA.	Mathematics.	• Academic performance (mathematics): d = 0.16 • Student motivation for learning: d = 0.09
Prtljaga & Veselinov (2017) [34]	PBL experience.	120 students (9-10 years) from primary schools in Vrsac, Serbia.	Social sciences.	• **Reproductive knowledge: d = 1.40** • **Understanding of knowledge: d = 1.03** • **Application of knowledge: d = 1.39**
Siswono *et al.* (2018) [35]	PBL experience on statistics. 8 weeks.	72 students (12-13 years) from a secondary school in Surayaba, Indonesia.	Mathematics.	• **Academic performance: d = 2.34**
Sola & Ojo (2007) [36]	PBL-centered experience on the subject of chemistry. 6 weeks.	233 secondary school students from Osun, Nigeria.	Natural sciences (chemistry).	• **Academic performance: g = 1.73**
Storer (2018) [37]	PBL-centered experience that uses technological resources. 6 weeks.	90 students (9-10 years) from a primary school in Auckland, New Zealand.	Technology.	• Creative skills: d = 0.25
Worry (2011) [38]	PBL experience with hands-on activities with disadvantaged students. 2 weeks.	65 students considered high risk from a secondary school in Texas, USA.	Mathematics.	• **Academic performance: g = 0.60** • **Satisfaction with education: g = 1.40**
Wright (2009) [39]	PBL program and use of technology. 104 weeks.	1,423 primary and secondary school students (11-16 years) from Florida, USA.	Various.	• Reading comprehension: d = 0.00 • **Involvement: d = -0.17**

* In bold, the statistically significant results in CI = 95%. d = Cohen estimator; g = Hedges estimator; ES = effect size as given by the study. A standardized value of the effect is presented for all three estimators (values around or below 0.2 indicate a small effect; values around 0.5, an average effect; values around or greater than 0.8, a great effect).

Source: Author's creation.

What impact does project-based instruction and schools of interest have on student learning?

Both the reviews and the primary studies analyzed lead us to conclude that we have evidence that PBL has a positive impact on academic performance. The same cannot be said about PBL's impact on the affective and motivational aspects of learning, where the results are mixed, or on the acquisition of crosscutting skills, where the evidence is scarce.

- **Academic performance.** PBL is linked to a medium-large positive effect on students' academic performance.

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  PBL is linked to a positive effect with a medium to large magnitude on students' academic performance [1]. If we compare this impact with that of other internationally evaluated programs, like the Education Endowment Foundation, for example [40], PBL shows greater effectiveness than that attributed to programs based on student feedback, on the promotion of meta-cognition and self-regulation of learning and on personalized tutorials.

  The primary studies reviewed support this conclusion: the causal evidence is scarce, but points to a slightly positive impact on learning. Evidence from quasi-experimental studies is more abundant and shows a positive and medium impact on learning.

  This positive effect can occur both on conceptual and procedural knowledge about content, and some studies emphasize the possibility of students integrating conceptual knowledge applied through PBL [8].

  It should be noted that our review of the literature also shows some studies with zero impact, an impact limited to certain capacities or even a negative impact [15] [16] [18] [41]. These mixed results can be explained by the diverse learning experiences evaluated and PBL's high sensitivity to the context and the conditions in which it is employed. It may also be due to the different evaluation methodologies used.

  Furthermore, most studies measure the learning outcomes just after the program ends, so we can only evaluate the effects in the short term.

- **Affective and motivational aspects of learning.** PBL is related to a positive effect on student satisfaction with the teaching experience, but the evidence is mixed with regard to the effects on their motivation for learning, involvement and assistance.

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  Students generally show positive attitudes towards this methodology [12]. PBL is usually viewed positively by students, which leads them to judge it as more effective than traditional methodologies [14]. This subjective perception is probably related to some effects

suggested by research: when PBL is used, students can develop a better view of science and better expectations of pursuing a scientific career [9], a better self image [11] and improved perception of their self-efficacy [8].

However, when the impact of PBL on students' intrinsic motivation and involvement in learning is measured, the results are less conclusive. Based on our review of 10 primary studies, we find that PBL's effect on motivation and involvement is not significant enough.

When the impact on student attendance and completion of the programs is measured, the results are equally inconclusive. Based on five primary studies reviewed, there is a very slight effect on levels of attendance and on preventing students from dropping out.

These results alert us that it is one thing to stimulate student satisfaction regarding the use of PBL compared to traditional methodologies, but it is quite another to achieve a real impact on their intrinsic motivation and their attendance in the classroom. The first goal seems relatively achievable, but the second is more difficult.

- **Crosscutting skills.** We do not know if PBL has a positive impact on the acquisition of skills such as creativity, critical thinking or digital competence, given the absence of evidence in this area.

There is an observable and widespread lack of assessments on PBL's impact on personal and social skills, which prevents us from commenting on it [8]. However, some reviews suggest that PBL could be an effective methodology for teaching complex processes such as planning, problem solving and decision-making [14].

We do not know if PBL has a positive impact on the acquisition of skills such as creativity, critical thinking or digital competence, given the absence of evidence in this area.

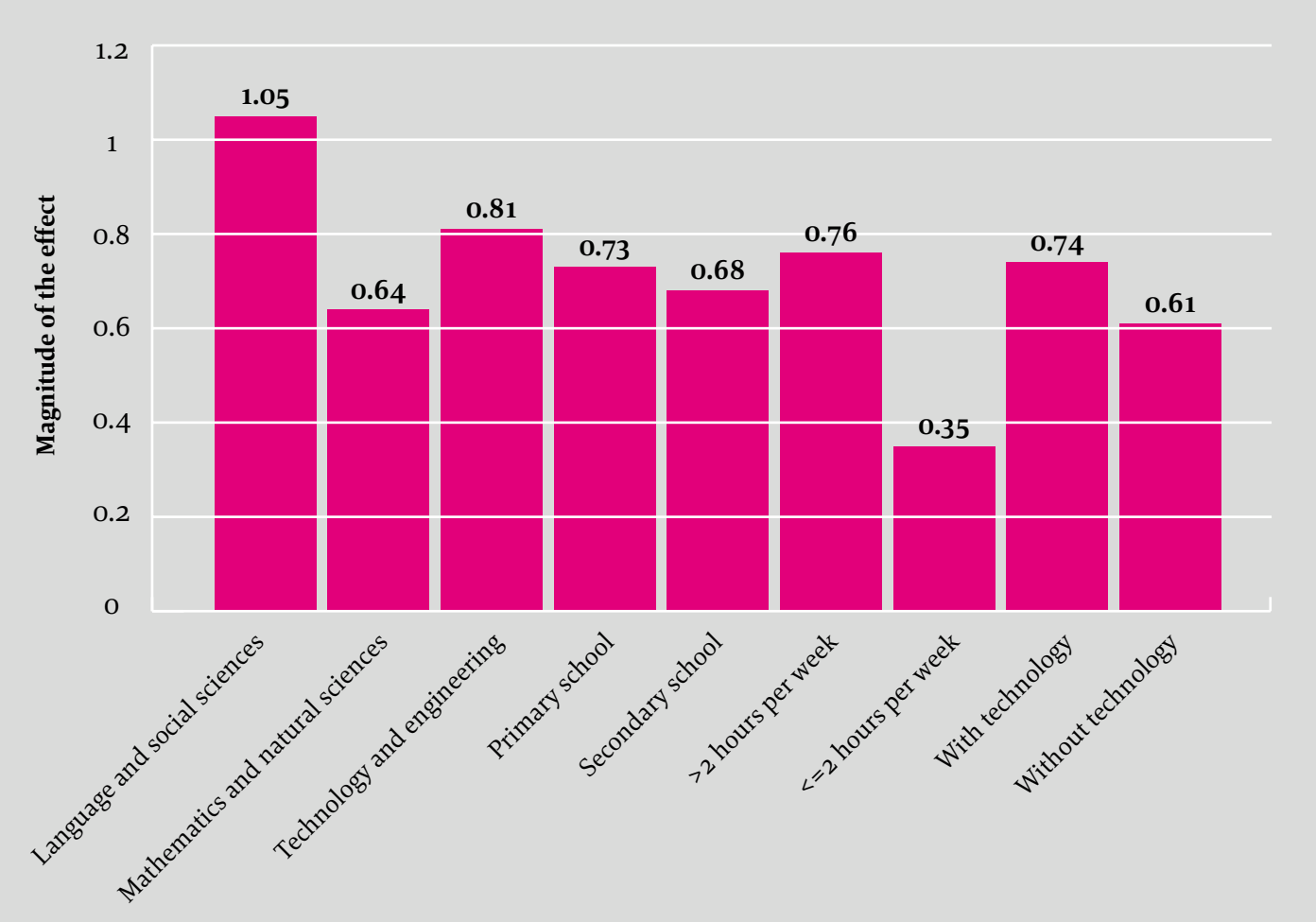
Two primary studies have been identified that evaluate the impact of PBL –one on critical thinking and another on creativity– but the results are not statistically significant. Through qualitative assessments, other reviewed primary studies point to more optimistic results. For example, an experimental study [19] reports positive results on collaborative work skills in the context of using computers in secondary school. Another experimental study on the area of language in several secondary schools in the United Kingdom [41] shows a possible positive effect on students' collaborative and self-regulatory skills.

What are the characteristics of the most effective programs for project-based instruction?

- **Subject or curricular area.** PBL is associated with a great effect on languages and the social sciences and the effect is between medium and high in science, technology and mathematics. Multidisciplinary projects attain mild effects.

  The areas of knowledge where the programs are most effective are those of the social sciences and languages, where they have a great effect [1]. The primary studies that we reviewed have a generally medium impact on these two areas. It is likely that teachers in languages and social sciences feel that their contents require less sequencing, which makes it easier to have a more flexible approach during project work; this context may be different in mathematics, science, and technology where teachers may consider that the course contents require more fixed sequencing, setting limitations on how the contents are addressed during the project. In fact, the impact on the natural sciences and mathematics is also positive, but at a medium value.

Graph 1.
Effect of PBL according to various moderating variables [1]



Average magnitude of the effect based on various variables according to Chen and Yang [1]. In bold, statistically significant values in CI = 95%.

PBL offers good results for technology, to great effect, though we also identified two primary studies in this area with insignificant results. Finally, we found 23 primary studies with multidisciplinary programs that have a generally positive but mild effect. The fact that some of these programs include crosscutting projects, which call for close coordination and joint action by teachers, could help to explain this lesser effect.

PBL is associated with a great effect on languages and the social sciences and the effect is between medium and high in science, technology and mathematics.

- **Intensity and duration.** PBL programs are more effective when more than two hours per week are devoted to them. The programs are more beneficial when they are concentrated into a few weeks**.**

The PBL programs with better results are those that devote more than two hours per week.

The PBL programs with better results are those that devote more than two hours per week, compared to those who spend less time [1]. It seems that one-off activities with no follow-up (like one session per week, for example) and without sufficient time to plan, begin research and promote reflection are less effective. In our review of primary studies, we found that the programs with the best results last between six and eight weeks. Thus, programs could benefit by seeking out a learning experience concentrated into a few weeks–that is, by applying an occasional and intensive PBL model rather than turning it into a ubiquitous experience at school and replacing any other form of education.

- **Use of digital technology.** The programs are more effective when using technological tools so the students can access better information and establish better collaboration.

PBL programs are more effective when using technological tools than when not [1]. The simple addition of technology does not improve learning outcomes, but it does help students to gather more and better information for their project and to collaborate more efficiently, sharing an interface and resources to solve the problems posed. Technology supports the success of PBL as students can document their project and share their digital creations comfortably [10]. It is important that technology be used as a cognitive tool for students, and not just to support teaching [14].

For whom are project-based instruction programs most effective?

- **Level of education:** There are no differences in the impact on primary and secondary school students. The research on childhood education is still hard to come by.

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There are no differences in the effect of PBL on primary and secondary school students [1]. The primary studies that we reviewed also confirm an effect similar to those in primary and secondary school. Furthermore, research on children's education is scarcer and there is not enough evidence to be useful, though there are some studies with generally positive results [10] [12].

- **Student profile.** We cannot say that disadvantaged students benefit from PBL to the same extent as the rest, since there is little evidence for it and the indications are mixed. Research on the differential impact according to the students' gender is small and shows equally mixed results.
We cannot comment on whether PBL benefits students disadvantaged by socio-economic or performance issues to the same extent as the rest of the students, since what little evidence there is shows mixed results.

We cannot say that disadvantaged students benefit from PBL to the same extent as the rest, since there is little evidence for it and the indications are mixed.

This is indicated by both the reviews [13] and the primary studies analyzed. We found research that shows better involvement or results in students disadvantaged by their ethnic or socio-economic origin [38] [42] [43]. We also found studies showing that the results of PBL are not related to the students' status [44] and that PBL can benefit privileged and disadvantaged students equally [45]. We can find evidence indicating that the impact on disadvantaged students is insignificant [17] [28]. Finally, we also find evidence suggesting that PBL can be problematic for underprivileged students: an experimental study [41] with a sample of over 4,000 students shows a negative impact on socially and economically disadvantaged students.

The initial status of the students' previous knowledge and abilities seems to be a key factor in PBL. Students who begin from a worse initial position encounter an educational activity where they must exercise high levels of autonomy and self-direction, meaning that it depends heavily on their previous knowledge and ability to manage the project. Therefore, in order to achieve good results, teachers will likely need to follow these students closely via formative assessment and guide them during the project, offering the students a lot of help at the beginning and less as the project advances so they can acquire more autonomy. Likewise, the proper design of all the sessions, their curricular consistency and the use of authentic interdisciplinary activities are key factors in some effective experiences with disadvantaged students (Box 2).

Box 2.

The characteristics of a beneficial PBL experience for socially and economically disadvantaged students

Two different projects called "Production and producers in our community" and "Children, citizenship and community" are being implemented in different schools in the state of Michigan in the United States [42]. It is a PBL experience in the social sciences and language in primary school that manages to close the gap in results between low and high socio-economic students. Each project includes about 20 work sessions of 45 minutes each. Following a *formative assessment* perspective, information is collected on the development of the project and the students' actions and the researchers and the teaching staff share their assessments and *repeatedly make changes to improve the project*. The teachers follow the educational programs throughout the projects faithfully but flexibly.

Both projects have features in common, since they:

- Involve issues that have *a connection with the students' environment and that are linked to aspects worked on in other lessons*;
- Include activities where students must explore a topic through data or a day trip.
- Integrate the areas of language and social sciences into the activities, and these activities *align with the state curriculum*;
- Culminate with a product to be presented well beyond school;
- Have sessions that follow a similar format: they begin with a speech-dominated activity involving the entire class (5-10 minutes), followed by guided work in small groups or individually (20-30 minutes), then by a *review* or *reflection* with the whole class (5-10 minutes).

At the end of the experience, there was a positive effect on disadvantaged students in their performance in reading (+0.29) and the social sciences (+0.31) compared with the privileged students.

For further information:

Halvorsen, A. L., Duke, N. K., Brugar, K. A., Block, M. K., Strachan, S. L., Berka, M. B., & Brown, J. M. (2012). Narrowing the achievement gap in second-grade social studies and content area literacy: The promise of a project-based approach. *Theory and Research in Social Education, 40*, 198-229.

Studies have been carried out that have shown beneficial effects for special education students, such as in terms of disciplinary knowledge, self-efficacy, and attitudes towards the group [46], as well as in the sense of creating a more inclusive environment than traditional teaching [47] [48].

Regarding the students' gender, there is a lack of evidence and the mixed results prevent us from drawing any conclusions today about whether PBL has a different effect on boys and girls. We can find some studies that show a greater benefit for boys [21] [49] [50] and others that show a higher impact for girls [51-53].

There is a lack of evidence and the mixed results prevent us from drawing any conclusions today about whether PBL has a different effect on boys and girls.

Should this educational practice be expanded in Catalonia? Which conditions should be met?

Given the answers presented thus far, it seems appropriate to recommend PBL as a methodology to improve the learning of Catalan students, especially with regard to their academic performance in the area of languages and social sciences, and to a lesser extent in mathematics, science and technology.

Nevertheless, the literature suggests that this improvement is not automatic or guaranteed simply by implementing PBL programs, but is linked to key factors that operate at different levels of the education system (Box 3). These are factors that could act as levers of change for the effective introduction of PBL into the Catalan educational system: school leadership, the combination of PBL with direct instruction methodologies, teacher training and political leadership. The role of school leadership and the importance of embracing global changes in schools that allow for cultural changes and the effective integration of PBL into the school's educational project (Box 4) are also worthy of note.

This improvement is not automatic or guaranteed simply by implementing PBL programs, but is linked to key factors: school leadership, the combination of PBL with direct instruction methodologies, teacher training and political leadership.

Font: El·laboració pròpia

Box 3.
Key factors that influence the successful implementation PBL programs

Implementation can be more effective when incorporated into global changes at school. Effective programs are often accompanied by school leadership that facilitates organizational change and coordination between teachers.

Some studies [54] [55] [56] suggest an approach that addresses the methodological changes in the school as a whole. PBL is more likely to be effective when the principles of the approach are consitent with how the school and the educational system operate and are organized [12]. School leadership plays an important role in creating spaces so that teachers can coordinate and help each other and evaluate the students formatively [8] [10]. The school administration counteracts the everyday difficulties that the teaching staff encounters, such as inflexible schedules and strict limitations on time [14].

PBL can be more effective when the teachers help all students, promoting a mix of direct instruction and independent research.

Many students experience difficulties in starting the projects and leading them autonomously [14], which shows the key role that teachers (and their colleagues and technology) can have in helping them. According to some reviews [10], successful projects are those that mix direct instruction (for example, content presentation) with independent research. Thus, we propose developing the project in two phases: a first phase in which the students receive instruction on the knowledge and skills needed to start it and a second phase in which the project develops more autonomously.

Teacher training plays a central role in overcoming difficulties and frequent reluctance in PBL.

PBL often produces reluctance among teahcers, much of which stems from their inexperience in managing this methodology, and to a paradigm shift from teaching centered on faculty to one focused on students [8] [12] [14]. Improvement in their training can help to placate many of these concerns, implementing training before the program starts and again during it once it is under way [8] [12]. The reviews suggest strategies such as exposure to modular experiences [8] [11] [14], the creation of school and teacher networks [10], the availability of mentoring by expert teachers [12] [14] and the provision of proper teaching materials [8] [14] and digital technology tools, as well as guidance on how to use them [8] [14].

Effective PBL programs are often supported by clear political leadership and a stability that fosters consistency between PBL and other elements of the macrosystem. The low costs of the programs can encourage their implementation.

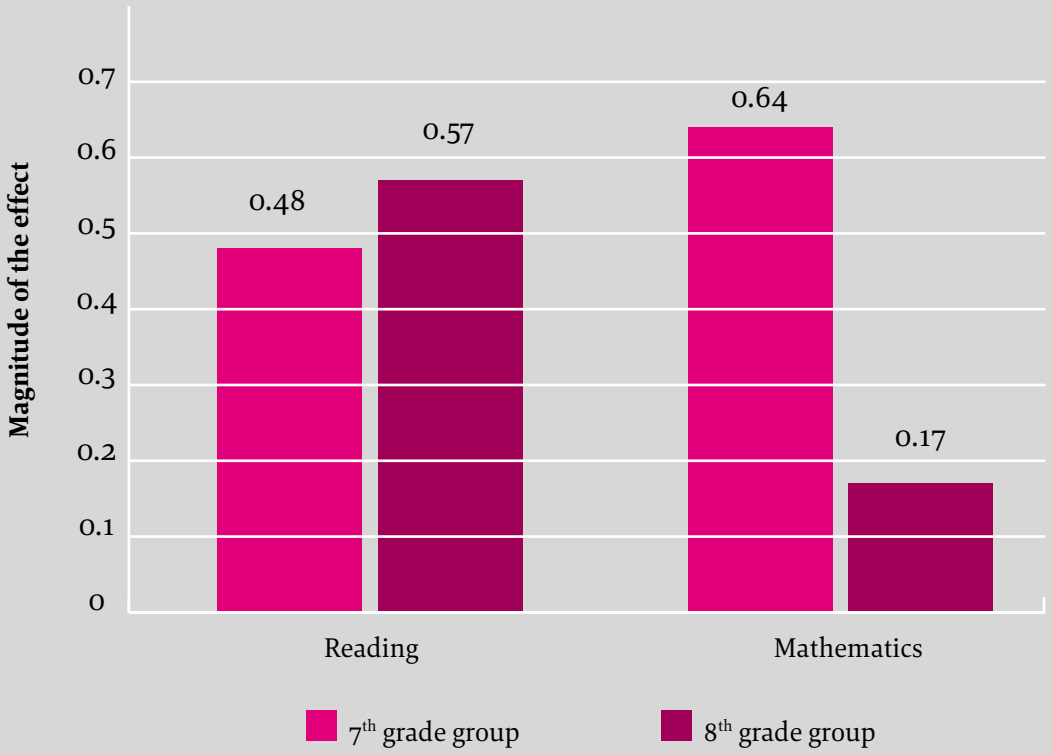
Teachers may get the feeling that they are doing a job "outside the system" if it does not align with PBL's own features [12] and this can lead to superficial experiences [14]. That is why the success of the programs is made easier when the school's inspections and the external evaluation of the students align with the objectives of PBL. The use of external evaluations that place too much value on curricular content and that do not work on skills typically promoted by PBL can inhibit the authentic use of project-based instruction [10]. However, some studies [41] suggest low costs for these programs: £58 per student per year, plus teacher training costs, which can encourage their implementation by educational leaders.

Box 4.
Redesign of a school through global changes

Cervantes et al. [25] analyze the case of a middle school for students from 12 to 14 years old in a district in southern Texas that had poor academic results, a poor academic reputation and low rates of low enrollment. A large proportion of the school's students came from ethnic minorities in the United States and from socially and economically disadvantaged classes.

The school district managers decided to seek help from the US Department of Education to completely redesign the school's practices and turn project-based instruction into an essential part of their educational project. This entailed implementing teaching practices that were beneficial for the disadvantaged students by adopting an innovative approach that affected the entire school. An outstanding aspect of the new educational approach was the work on authentic problems, as the students' projects revolved around a question or issue that was relevant to their life or their community. Therefore, the students ended up generating products connected to their life experiences. The PBL combined multidisciplinary work with in-depth work in specific subjects to achieve a good knowledge of content. Similarly, collaborative learning was essential for project-based instruction.

The researchers evaluated the results in one group of 7th grade students (87) and in another group of 8th grade students (84) where PBL was used. A group of 7th grade students (140) from the same school and a group of 8th grade students (150) were used as control groups where PBL was not used. It was found that students who followed PBL systematically exceeded the control group in mathematics and reading, with the following magnitudes of the effect:



Educational administrators and teachers assumed a great deal of uncertainty in the implementation of the program, since the school's funds depended on the external evaluation carried out by the administration and it did not evaluate elements associated with PBL (the ability to manage a project, student autonomy, etc.). The assessment of the experience established the need for teachers to find the time to develop new materials, to learn new pedagogical and evaluation techniques and to manage the classroom differently. Thus, Cervantes et al. [25] recommend that this training be continuous and that the school administration provide flexibility in managing the school's budget, curricular design and hiring practices. The authors indicate that the help of educational administrators and leaders of the administration provided through mentoring is key to promoting authentic changes in teachers.

For further information:

Cervantes, B., Hemmer, L., & Kouzekanani, K. (2015). "The Impact of Project-Based Learning on Minority Student Achievement: Implications for School Redesign". *Education Leadership Review of Doctoral Research,* 2(2), 50-66.

Summary

There are indications that PBL has a positive and moderate impact on students' academic performance, though the evidence is mixed. The magnitude of the effect is large on social skills and language and more moderate on mathematics, science and technology. PBLs are also observed to be associated with high levels of student satisfaction regarding their educational experience. However, the evidence is inconclusive regarding the effects on their intrinsic motivation, involvement and attendance in the classroom. Given the dearth of evidence, we do not know the impact on cross-disciplinary skills such as creativity, critical thinking or digital competence.

No differences are observed in the effect on primary and secondary school students and research in early childhood education is still hard to come by. Programs are more effective when they last more than two hours per week and project programs that last from six to eight weeks could be even more beneficial. Programs are more effective when students can use digital technology to access information and establish better collaboration. We do not know whether disadvantaged students can benefit from PBL in the same way as others, since the little evidence in this respect is contradictory. We are also unable to identify a different impact according to the students' gender.

The mixed results on the impact of PBL suggest that this depends heavily on the context and the conditions of their use. Our review of reviews concludes that the success of PBL can be supported by certain key factors:

The mixed results on the impact of PBL suggest that this depends heavily on the context and the conditions of their use.

- Implementation of school-wide changes and strengthening of the school's leadership to provide the right teaching conditions.
- Adequate teacher guidance of all the students learning, for example through a combination of direct instruction and independent research.
- Initial and continuous teacher training.
- Political leadership and systemic consistency.

Table 4.
Strengths and limitations of PBL

Strengths	Limitations
Moderate improvement in academic performance	There is little evidence to justify causal inferences
Especially suitable for language and the social sciences	Multidisciplinary programs yield more discreet results
Improvement in student satisfaction	Evidence is mixed regarding the impact on intrinsic motivation and class attendance
Valid for supplementing direct instruction (no need to replace it)	There is a lack of evidence about the impact on crosscutting skills
Students can take advantage of digital technology	The evidence is inconclusive for different impacts according to the students' gender and socio-economic situation
Equally suitable for primary and secondary education	We do not know about its impact on children's education
The programs can be a low cost	Requires initial and continuous teacher training
Methodological change can prompt cultural changes in the schools (more collaboration, teaching focused on students)	Requires school-wide and systemic changes

Source: Author's creation.

Implications for practice

PBL can be a tool for **improving the outcomes of primary and secondary students, especially in language and the social sciences**. PBL can also be used to improve students' satisfaction with their educational experience. However, it cannot be recommended as a methodology that prevents students from dropping out of school, since its impact on other variables is poorly understood. We also do not know the impact it can have on crosscutting skills such as creativity, critical thinking and digital competence. PBL cannot be recommended to reduce the inequalities of disadvantaged students or to reduce gender gaps.

We recommend that implementation of this type of program include **rigorous evaluation of its impact on key crosscutting skills** for our students, such as collaborative work or critical thinking, since it is precisely these types of skills that seem more likely to improve through an active methodology like PBL. It is also recommended that these evaluations include key variables regarding the students, such as their socio-economic status and their gender, in order to evaluate any differential impacts.

In general, PBL may serve as a lever to improve students' academic outcomes, but at the same time it **requires effort from different stakeholders in the educational system. The effectiveness of PBL is not automatic or always ensured, but depends heavily on the conditions of implementation**. The policies and practices of project-based instruction would have to achieve some decisive factors:

In general, PBL may serve as a lever to improve students' academic outcomes, but at the same time it requires effort from different stakeholders in the educational system.

1. **Global school-wide changes must be made coming from the school's leadership**. PBL must be implemented as a collective school enterprise, fostering a teaching culture focused on students and collaboration that will makes teachers coordinate and help each other. The role of the school administration is key to integrating PBL into the school's educational project and to counteracting everyday problems such as inflexible schedules and inadequate spaces.
2. PBL must be implemented to **complement the teachers' instruction, and not to replace it**. Some studies recommend developing an initial phase aimed at direct instruction and modeling, followed by one devoted to independent research. Project-based instruction seems more effective when applied intensively and lasts for a few weeks. These results suggest that PBL is more effective when combined with other forms of teaching at school.
3. It must be ensured that **the teachers can guide all the students' learning**. Therefore, students must be helped in creating content for and managing the project, especially those that start from a worse initial situation. The use of formative assessment and the careful design of the sessions and activities connected with the students' situations seem key to some successful experiences with socially and economically disadvantaged students.

The use of formative assessment and the careful design of the sessions and activities connected with the students' situations seem key to some successful experiences with socially and economically disadvantaged students.

4. There must be **initial and continuous training for teachers** focused on project-based teaching skills and a shift in attitude towards teaching focused on the students. Training strategies have been proposed like the creation of mentoring programs among teachers and school and teacher networks to share resources and experiences.

Training strategies have been proposed like the creation of mentoring programs among teachers and school and teacher networks to share resources and experiences.

5. There must be a **political leadership that creates the systemic consistency necessary to facilitate PBL**. It is especially necessary to align the external evaluation with the objectives of the PBL. As such, the administration must align school inspections and external evaluation of the students' learning with the PBL's objectives.

The administration must align school inspections and external evaluation of the students' learning with the PBL's objectives.

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