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Consequences of Metaphor Frames for Education: From Beliefs to Facts Through Language

Abstract

This paper investigates the inferences stemming from two opposing metaphorical portraits of current educational methods (i.e., knowledge-transfer vs. knowledge construction metaphors) in contrast to the facts revealed by the actual teaching practice, and its implications for educational policy programs. To this effect, we tested the influence of the aforementioned conceptual metaphors on 100 parents with children enrolled in primary education in relation to four criteria (i.e., perceived difficulty, effect-iveness, entertainment, and motivation towards teaching methods), and then conducted a study among 8 class groups (198 students) at the 6º level of primary education (i.e., between 9 and 10 years old) of 4 schools in Logroño (La Rioja, Spain) to confirm whether the inferences stemming from each of the education metaphors under consideration were mirrored in the classroom. In this experiment, students were randomly assigned to one of the two teaching methods corresponding to each of the conceptual metaphors targeted in this study (i.e., Direct Instruction for teaching is knowledge-transfer and Project Based Learning for teaching is knowledge-construction). The results show a significant gap between parents' inferences emerging from the conceptual metaphors on education and actual students' performance in the experiment. Both the actual learning results and the students' perceptions about the difficulty, entertainment, and motivation of each methodology contradict the adults' expectations based on the inferences they had drawn from these two conceptual metaphors, thus showing an unfounded prejudice of parents' against DI's methodologies. We discuss the implications of this research for the current debate about teaching methodologies in Spain (and other countries), and the need for evidence-based implementation of new educational policies.
Keywords: conceptual metaphor; conceptualization; teaching methodologies; educational policy programs

1 Introduction

Conceptual metaphors project knowledge about a familiar or concrete notion (source domain) onto an abstract or less familiar concept (target domain) to facilitate its understanding and communication. It is pervasive in human communication, with some studies claiming that 20% of discourse has the potential to be understood in metaphorical terms (Steen et al., 2010). Metaphors have been found to influence thought, affect behaviour, and tamper with our memories. Evidence of these and other conceptual effects of metaphor has been mounting in the last few decades (Thibodeau et al., 2017).

The current educational debate in Spain revolves around two distinct teaching methodologies, Direct Instruction and Project-Based Learning. The discourse and rationale behind each of

these methodologies are based on two specific metaphors about the nature of the teaching/learning process, respectively: TEACHING IS KNOWLEDGE-TRANSFER and TEACHING IS KNOWLEDGE-CONSTRUCTION. The present study seeks to investigate the framing effects of these metaphors on parents' perceptions of the education process and to correlate them with the actual performance of students in Spain. To this end, we recruited 100 parents of children enrolled in primary education online via www.prolific.co to answer a short questionnaire about their perceptions of teaching methods, and we also involved 198 students of 6º Educación Primaria (i.e., between 9 and 10 years old) of 4 schools in Logroño (La Rioja, Spain) in a short experiment involving the two teaching methodologies (although we cannot be sure, we do not expect anyone in the two groups to be related). By contrasting parents' expectations with students' performance, we aim to offer an evidence-based diagnosis of how these conceptual metaphors influence Spanish society's perceptions of education with a view to guiding the development of more effective educational policies.

The first goal of this paper is to assess the influence of these two mainstream conceptual metaphors about education on the inferences that people draw about the teaching methodologies associated with them (i.e., Direct Instruction and Project-Based Learning). The research question driving this first objective is the following:

RQ1. To what extent do conceptual metaphors about education have an impact on adults' and students' inferences about the educational process?

To this effect, in *Study 1* (p. 9) we asked both groups (parents and students) to rate several criteria in relation to each of the teaching methods under scrutiny, namely perceived difficulty (how hard or easy they think the task is), perceived degree of comprehension (how much they believe they have learnt), degree of entertainment (whether or not they had fun during the session) and degree of motivation (whether or not the found the session engaging enough to repeat another similar task soon). Adults based their ratings on the expectations raised by the metaphorical frames that underlie everyday life conceptualizations and conversations about the teaching methods (i.e., TEACHING IS KNOWLEDGE-TRANSFER and TEACHING IS KNOWLEDGE-CONSTRUCTION, respectively). Children assessed the actual teaching methodology used in each of the interventions designed for the experiment.

The second objective is to assess whether the way the students are taught (i.e., Direct Instruction vs. Project-Based Learning) carries implications for the learning process. We seek to investigate (1) whether the teaching methodology affects the result of the learning process and if so, the extent to which it has an impact; and (2) whether it matches parents' expectations about such methods.

More specifically, the research question driving this research goal is formulated as follows:

RQ2. To what extent does the teaching methodology (i.e., DI vs. PjBL) have an impact on the student's performance, and to what extent does it contrast with parents' attitudes towards the educational process?

Study 2 (p. 12) was designed to compare the data collected regarding the parents' expectations about the effectiveness of each teaching method with the accuracy of the students' responses within each teaching method group. Children were taught a generally underrepresented aspect of second language learning (i.e., the necessary metapragmatic information in the successful performance of the act of requesting) using the two different teaching methodologies under scrutiny: Direct Instruction (associated to the EDUCATION IS KNOWLEDGE-TRANSFER metaphor) and Project-Based Learning (connected with the EDUCATION IS KNOWLEDGE-CONSTRUCTION mapping). Students were divided in two groups and both of them were taught according to the postulates of each teaching method. We then contrasted the effectiveness of each method (operationalized in terms of accuracy of responses), with parents' ratings about how effective they perceive each method to be in the acquisition of new concepts.

This paper is structured as follows. Section 2 presents the theoretical grounds of the study in relation to (1) the framing effects of conceptual metaphor, (2) the metaphors of education, and

(3) their association with different teaching methodologies. Section describes the methodological aspects of the study (i.e., participants, stimuli, experimental procedure, coding, and statistical analysis). Section presents the results of the studies and discusses their relevance in relation to the initial research questions. Section provides some conclusions and suggestions for further research.

2 Theoretical Background

2.1 Metaphors as Framing Devices

Since the foundational works by Lakoff and Johnson (1980) and Lakoff (1987), Conceptual Metaphor Theory, which later evolved into the Contemporary Theory of Metaphor (Lakoff, 1993), has provided ample evidence of the ability of conceptual metaphors to help speakers understand and talk about abstract or complex notions by projecting onto them their knowledge of more concrete, embodied, or topological concepts. The role of metaphor in shaping or influencing thought, behaviour, and memory initially received a smaller amount of attention but has gradually become a topic of interest and there is an increasing body of evidence based on a growing number of investigations (see Thibodeau et al., 2017, for an overview).

The ability of conceptual metaphor to shape our thoughts and influence our decisions has been made manifest in several studies. In a well-known experiment, Thibodeau and Boroditsky (2011, 2013) showed that people would choose different strategies to attempt crime reduction depending on the metaphor at work, with enforcement-oriented strategies being associated with the crime as a monster metaphor, and education-oriented strategies being preferred when the crime was presented metaphorically as a virus. Elmore et al. (2017) provided evidence of the way in which alternative metaphors of intelligence as light bulbs or seeds influence the ratings of inventors. Thus, male geniuses were found to obtain higher rates if their ideas were described as light bulbs, while female inventions received better grades when described as seeds. The conceptualization of cancer as an enemy and its treatment as a war or fight has also been analyzed in relation to its framing effects. An extensive body of literature has revealed that this metaphor can have negative effects on patients' morale and attitudes toward their illness (Hauser & Schwarz, 2015, 2020; Hendricks et al., 2018) and it can also influence the clinical practice and treatment of the disease (Oronsky et al., 2014). Recently, the metaphorical conceptualization of the COVID-19 pandemic in terms of war has also been shown to interfere with people's perceptions and support for covid policies (Schnepf & Christmann, 2022).

Metaphors can also affect our reactions and behaviour, having been found to increase students' motivation (Duit, 1991; Landau et al., 2014). In a previous study by Dweck (2008), the metaphor of the brain as a muscle that can be trained was shown to move students to adopt an incremental rather than fixed theory of intelligence, which increased their commitment to their learning goals.

Even our memories of past events can be influenced by the metaphors used in their descriptions (Mio et al., 2005; Pearson et al., 1981), including the creation of false recollections (Blanchette & Dunbar, 2002; Vendetti et al., 2014).

The literature on the framing effects of metaphor is, however, not fully conclusive. There have been studies that maintain that conceptual metaphor is not capable of influencing human reasoning in the way suggested by the aforementioned investigations. Steen et al. (2014) carried out four experiments to replicate Thibodeau and Boroditsky's (2011) findings, adding a control condition not included in the original proposal and other methodological adjustments. The results of their investigation showed no metaphorical framing effects. Panzeri et al. (2021) likewise reported on the lack of effects of the use of the war metaphor during the COVID-19 pandemic in people's reasoning about the pandemic by default. Their data reveal that individual variables such as the speakers' political orientation, however, do favor the acceptance of metaphor congruent entailments. Inconclusive results about the metaphorical frame effects of the war metaphor against COVID-19 have been also reported by Benzi and Novarese (2022).

The present investigation contributes to the ongoing debate about the ability of conceptual metaphor to influence human thought. This issue is of special relevance in the context of the elaboration and implementation of social policies. The following section looks into the specific area of education and provides a review of the literature on the metaphors that are at work in its conceptualization.

2.2 Education Metaphors and Teaching Methodologies

The main objective of this investigation is to find out whether the metaphorical framing of education contributes to triggering frame-consistent statements that prompt structurally consistent inferences, on the one hand, and whether those inferences fit the facts observed in real learning practice. Being aware of the potential framing effects of education metaphors is essential to the design of effective educational policies (Hager, 2008). As Schön (1993) pointed out, metaphors are generative because they lead us to think in new ways and implement changes. In an issue as sensitive as education, it is essential to be aware of the mental paths that different metaphors open for us and whether these paths can really fit the expectations that they create.

There are many metaphors that guide our understanding of education (e.g., EDUCATION IS PREPARING MENTAL MEALS; LEARNING IS POURING WATER INTO A JUG, etc). In the context of ESL learning, teachers have been metaphorically conceptualized as providers (of knowledge), challengers/agents of change, nurturers, innovators, providers of tools, artists, repairers, or gym instructors, among others (see de Guerrero & Villamil, 2002, for a comprehensive analysis). The learning process and its many facets are talked and reasoned about with the help of conceptual projections such as the CHILDREN ARE SPONGES (fast learners) or CHILDREN ARE BAMBOO (initial slow progress that accelerates passed a critical stage) metaphors. Conceptual metaphors about education range from the aforementioned well-known, fossilized mappings to more creative ones such as the EDUCATION IS A TEA BAG metaphor, which communicates the fact that education contains the essence of knowledge which expands and is enjoyed throughout life, EDUCATION IS A WINDOW OR A MIRROR, EDUCATION IS A TRAIL OF BREADCRUMBS, EDUCATION IS A HARBOUR or EDUCATION IS A FLAME THAT NEEDS TO BE IGNITED (see Abad & Ruiz de Velasco, 2020, for an account of these and other metaphors found in the conceptualization of education).

In fact, as Hager (2008, p. 679) points out, "humans seem to be unable to think about learning without employing metaphors of some kind." In this paper we focus on two opposing conceptual mappings that currently dominate the debate about education policy in Spain. On the one hand, there is a traditional, highly intuitive metaphorical understanding of education which involves a view of the teaching/learning process as a transfer of knowledge from teachers, who are the repositories of that knowledge, to students, who need to acquire it (i.e., KNOWLEDGE-TRANSFER metaphor). This metaphor is knowledge-centered, in the sense that its goal is the students' *acquisition* of such knowledge. On the other hand, there is a more recent metaphor about education which is student-centered, recognizing their individual and cultural differences and allowing them a more active role in the learning process, in which students construct rather than acquire knowledge and teachers are mere guides or facilitators in this process of knowledge *construction*. This is the so-called EDUCATION IS KNOWLEDGE-CONSTRUCTION metaphor.[1] Each of these mappings underlies the discourse of two different models of education which parallel the epistemological distinction between behaviourist and constructivist theories of learning (Davis, 2020; Patchen & Crawford, 2011).

The KNOWLEDGE-TRANSFER metaphor is associated with a collection of teaching methodologies which fall under the umbrella term of *Direct Instruction* (henceforth DI). Developed by Engelmann and colleagues, DI is described by its proponents as an integrated system of curriculum

[1] These metaphors have received different labels in the literature: TRANSMISSION-GUIDANCE; ACQUISITION-PARTICIPATION, PRODUCTION-FACILITATION (Badley & Hollabaugh, 2012; Hager, 2008; O'Neill & McMahon, 2005; Sfard, 1998).

and instruction that aims at teaching a subject matter efficiently so that all students learn all the material in the minimum amount of time (Kinder & Carnine, 1991; Watkins & Slocum, 2003). To achieve this objective, DI places emphasis on the fine-grained design of the teaching materials (i.e., concepts, rules, strategies, and generalizations), the organization of instruction (i.e., scheduling, sequencing of skills and contents, grouping, progress monitoring), and the choice of student-teacher interaction techniques to ensure that every student is engaged and masters the objectives set for each lesson (i.e., active student participation, group unison responses, pacing, correction procedures, success-based motivation).

Defendants of DI claim that this teaching method is effective for students of all ages and language backgrounds and diverse learning profiles, including those with special educational needs. Contrary to the general belief, it is also stressed that DI, despite including a knowledge-based curriculum and not being student-centered, does not consist in teachers standing in front of a classroom presenting academic uncontextualized content to a group of students who listen passively to them and later memorize those contents and procedures. In fact, the active engagement and participation of students in the proposed learning activities is expected and encouraged by the teachers, who also must make sure that the contents, materials, and activities offered to students are neither too easy (and therefore, monotonous), nor too difficult (and hence, frustrating) for the students.

The effectiveness of DI is largely supported by research. One of the largest educational experiments in history, the *Follow Through* project, tested three types of outcomes (basic skills, cognitive-conceptual skills, and affective skills) after the use of different teaching methodologies. The project involved over 100,000 children from 170 communities throughout the United States and its experimental phase lasted from 1968 to 1976. DI was the only teaching method to demonstrate significant positive outcomes in all three types of skills. The positive assessment of DI has been later on ratified by many other studies and research meta-analyses up to date (Borman et al., 2016; Frampton et al., 2021; Gunn et al., 2021; Herman et al., 1999; Stockard et al., 2018).

In turn, the KNOWLEDGE-CONSTRUCTION metaphor is to be found in connection with methodologies that advocate a constructivist approach to learning, of which a prominent example is the Project-Based Learning method (henceforth PjBL). PjBL is increasingly being implemented in many Spanish primary schools throughout the country. PjBL is "an active student-centered form of instruction which is characterized by students' autonomy, constructive investigations, goal-setting, collaboration, communication and reflection within real-world practices" (Kokotsaki et al., 2016). Students work in collaborative groups, and teachers act as facilitators rather than as transmitters of information. Proponents of PjBL argue that the open-ended nature of this type of instruction increases students' motivation and enriches their creativity and reasoning skills (Campos-Roca, 2021), thus responding to the needs of the 21st century education. Research on this methodology has also flourished in recent times. PjBL has been explored in various contexts and in different phases of schooling, with many studies offering positive evidence that supports its use in order to help students improve their problem-solving capacities and academic achievement (Chen & Yang, 2019; Dochy et al., 2003). However, most research on PjBL has focused on higher levels of education (middle and high school classrooms, and college degrees; W. Parker et al., 2011; W. C. Parker et al., 2017). Evidence on the efficiency of PjBL in primary education is limited and most of the studies carried about with younger students do not include a randomized controlled trial design that would lead to clear causal conclusions about the impact of this teaching method (Duke et al., 2021; Kokotsaki et al., 2016). A recent metanalysis by Ferrero et al. (2021) focused on eleven studies comprising 722 kindergarten and elementary school students, all of which followed a pre-post design with control group and measured quantitatively the impact of PjBL on the content knowledge of students. The investigation revealed important methodological flaws and showed that the studies yielded inconclusive results. Even though the evidence on the benefits of the use of PjBL in primary education is far from compelling, its implementation in all areas of the curriculum is gaining momentum in Spanish primary schools, at the expense of DI.

All in all, Spanish education is nowadays characterized by the opposition between these two teaching methodologies: the traditional, knowledge and teacher-centered DI method, whose effectiveness in terms of learning outcomes is supported by ample evidence; and the more modern, student-centered PjBL method, whose implementation is growing even though evidence about its effectiveness is to date inconclusive. The discourse of each of these methodologies is anchored in the use of two opposing metaphors (EDUCATION IS KNOWLEDGE-TRANSFER and EDUCATION IS KNOWLEDGE-CONSTRUCTION). In the remainder of this paper, we seek to unveil the inferences that Spanish speakers draw from each of these metaphors on the advantages and disadvantages of each of the corresponding methodologies, and to assess their correlation with the existing evidence, as well as with that stemming from our own experiment. If education metaphors create any sort of framing effect, it is important to identify them prior to the development of future educational policies.

3 Methodology

3.1 Participants

For this experiment, we recruited 198 students of 6º Educación Primaria (i.e., between 9 and 10 years old) of 4 schools in Logroño (La Rioja, Spain). The reason why we targeted students of this academic level was because they were familiar with a range of formulas for requests in English (such as the use of the imperative, "can", "could" and "would") but had not studied them in depth or in a systematic manner. Textbooks in Spain do not touch upon the pragmatics of requests, and therefore it was to be expected that the contents, yet graspable, would be new for the students.

The schools were located in neighborhoods of similar socioeconomic characteristics and therefore they did not differ greatly in terms of the social, economic and educational background. All the students shared Spanish as their first language and English as their second language.

The study was framed as an extra-curricular activity by the schools' staff and therefore the students did not perceive any economic compensation for their participation in this study. Data collection took place during May 2022 by the two authors of this study.

Parents were recruited online through Prolific (www.prolific.co) and were compensated economically for their time according to the platform's ethical standards.

3.2 Stimuli

For the class intervention, we designed two lesson plans following the main teaching postulates of the two teaching methodologies under scrutiny (i.e., DI and PjBL, respectively). Each lesson plan had as its goal the teaching of 4 types of request formulae in English: IMPERATIVE, "CAN YOU DO X", "COULD YOU DO X" and "WOULD YOU DO X" constructions. For the situations presented in the three stages of the study (see the description of the experimental procedure below) we offered a wide range of subjects personifying the type of pragmatic variables involved in illocutionary production and interpretation in terms of social distance and power (ranging from parents and teachers to siblings and best friends); and in terms of social cost, we also chose objects and actions adapted to the students that presented different costs for them (ranging from asking for a cookie to a trip to Euro Disney).

3.3 Experimental Procedure

For the class intervention with students, the study comprised three stages: *instruction*, *practice*, and *final questionnaire*. In the first stage, *instruction*, we provided students with key information regarding the formulation of requests in English according to the variables of social distance, social power, and cost of the requested action.

As shown in Table 1, this study follows a between-subjects design for the first two stages (instruction and practice), where the 8 class groups recruited for this study (198 students) were randomly assigned to any of the two teaching methods (DI and PjBL) targeted in this research. The third stage (questionnaire) is a within-subject design because all the students answered the same eight assessment questions, aimed at evaluating their achievement in the learning of the pragmatic factors involved in the use of the different request formulae under consideration (as manifest in their implementation). For the purposes of this study, we took as a control group (and reference group in our linear models) the students that took part in the DI session, as this still is the usual practice in Spanish schools.

Table 1. Distribution of participants by experimental condition.

Participants	DI	PjBL
Students	98 (control group)	100
Adults	100 ratings for DI and PjB, respectively	

The design of the sessions was faithful to the DI and PjBL approaches, including the main essential components of each method as described in the literature. Therefore, we designed two interventions with their respective sets of materials. The first one was based on DI principles and consisted in one of the authors herself actively teaching the concepts to the group of students. To this purpose, she made use of a PowerPoint presentation and a set of dynamic exercises organized into tracks involving increasing difficulty and diverse student autonomy requirements. The students were thus guided by the teacher in the process of mastering the use of the different request constructions. The second intervention, in the spirit of PjBL tenets, was based on the autonomous work of students in groups. The other author of this study, acting as a facilitator, provided them with photocopiable materials with instructions that presented problems and activities related to the topic under scrutiny, so that they could lead their own way into the discovery of the final product (i.e., the request constructions that suit different contexts). In this stage, all students learnt about the differences between requests and other directive speech acts (i.e., orders), as well as about several request formulae in English and the social and transactional variables (i.e., social power, social distance, and social cost) that determine the choice of request constructions in different contexts of use. The authors of this study were always present to solve doubts and questions that students may have. As explained in Section 3.1, all students had the same prior basic content knowledge about the subject matter and similar competence in learning strategies and skills.

In the second stage, *practice*, we created two types of materials to check the understanding of the key concepts acquired in the first stage. In doing so, we designed two activities where students were presented with a situation in which they had to ask for something (of varying social cost) to a person in relation to whom students had diverse levels of familiarity and power asymmetries, e.g. "How would you ask your teacher to turn on the lights?". Two options were then offered, one of them more prototypical than the other in terms of the social distance, power, and cost involved in the situation (e.g., "Turn on the lights" vs "Could you turn on the lights?" where the latter would be the more prototypical one given the higher distance and power asymmetry between teacher and students).

Finally, in the third stage we distributed a *questionnaire* that students had to fill in individually, which was the source of the data gathered for the present study. Since we are interested in exploring the differences between teaching methods, the questionnaire was the same for all four groups. It contained 8 questions similar to those of the practice stage, where students were presented with a situation in which they had to ask someone for something and had to choose the most appropriate request formula in English. In addition to this, they then were asked to motivate their answers by selecting, on a scale from 1 to 5, the social distance estimated between themselves and the other

person in the situation (from 1, no distance, to 5, very distant), the social power (from 1, no power difference, to 5, a great power asymmetry), and the estimated social cost of the object or action requested (from 1, no social cost, to 5, great social cost). Finally, they also had to answer four questions about their perceptions of the session (whichhad lasted for around an hour and a half) in terms of *complexity* (they again had to provide answers on a Likert scale from 1, very difficult, to 5, very easy), *comprehension* (from 1, if they thought they did not understand anything, to 5, if they thought they understood everything), *entertainment* (from 1, if they found the session very boring, to 5, if they found it to be very fun) and *motivation* (from 1, if they would not want to repeat anything similar, to 5, if they were willing to repeat a similar session).

The interventions were performed in May 2022. Despite the fact that PjBL is traditionally executed over an extended period of time, the experiment was designed to carry out the DI and PjBL sessions in the same amount of time. This methodological decision was expected to allow for a comparison of knowledge learning results in relation to the time invested in achieving them, working under the premise that a sound methodology should also be cost and time efficient.

For the adults' group, parents answered a questionnaire for *Study 1* in which they had to rate the two methods for the same four subjective perceptions as the children (namely, difficulty, comprehension, entertainment, and motivation). For *Study 2* (p. 12), we added a fifth item: "perceived effectiveness", to be contrasted with the actual volume of "right" responses reported by children after taking part in the two teaching methods.

3.4 Coding

Once we collected all the answers from the final questionnaire, we coded how *accurate* they were according to the situation described (as this is the variable of interest in *Study 2*) (p. 12). We refrained ourselves from coding the students' answers as 'correct' or 'incorrect' as we did not mean to be prescriptive in the way we understood the students' performance; rather, we relied on the labels 'expected' and 'unexpected' (for prototypically correct and incorrect answers) given the contextual characteristics described in the task, as arguably both answers would be understandable by the hearer in all the cases.

'Expected' answers were coded when students chose the formulas "Could you X?" or "Would you X?" where the situation described involved high social distance, power, and/or cost (e.g., requesting one's boss for a promotion) or small social distance and high cost (e.g., requesting one's best friend to lend one his favorite car), as well as when they opted for "Can you X?" and the imperative when there were no social power asymmetries, the social distance was small, and/or the cost was low (e.g. requesting a close friend for a glass of water). The rest of combinations were coded as 'unexpected'.

There existed the possibility that some of the students would have different perceptions of the situation from that anticipated by the researchers (e.g., depending on whether they had older or younger siblings, they perceived the power asymmetry between them to be different; also, the distance between neighbors varied depending on their personal experience). Consequently, we revised the ratings provided for the answers coded as 'unexpected' to see if they were coherent with the answer given (we took values 1-2 as 'low' and 3-5 as 'high'), and following the rationale described above: they should have chosen "could" and "would" in all cases except when the situation involved low distance and cost, in which case they should have chosen "can" or imperative. Answers that were consistent with the students' interpretation of the situation were coded as 'possible', because, if not prototypically correct, they could be regarded as peripherically correct.

We obtained 1324 expected answers, 68 possible answers, and 176 unexpected answers. Finally, we combined prototypically correct with peripherally correct answers so that we ended up with a binary distinction between expected answers (1392) and unexpected answers (176) for the analysis. The reason to combine them is that we are interested in the extent to which teaching methods have an impact on justifiable answers given a specific situation, understood broadly –

including what is culturally and contextually expected and possible – versus what would come across as unexpected.

3.5 Statistical Analyses

For all statistical analyses, we used the R statistical programming environment version 4.0.2. (2020-06-22). In order to ensure the transparency, replicability, and reproducibility of this study, all the materials, data and code are available in a publicly accessible repository: https://osf.io/85t3d/?view_only=c2262807f3a64e0488b30abf04ac3c1e

For *Study 1* (the relationship between those inferences stemming from each educational metaphor and the subjective perceptions of the learning process; p. 9) we computed a linear regression model where methodology was entered as predictor, and the different subjective perceptions as outcomes. We calculated this for parents and children, respectively. No random effects were entered as there were no repeated measures. We then fitted the same models again but this time with type of participant as an interaction item in order to assess the extent to which perceptions of adults and students diverged in statistically reliable ways.

For *Study 2* (the relationship between the teaching method and the result of the learning process; p. 12), we computed a mixed linear regression model in which we entered the type of teaching methodology (which has two levels: DI and PjBL) as predictor and the accuracy of responses as outcome ('possible' and 'expected'). We opted for a regression model instead of a chi-square test of independence because it presumes some causality of the predictor (e.g., teaching methodology) of the outcome (accuracy in responses); and we chose binomial regression because the predictor has two levels. Our model is also mixed because each student answered the same final eight questions in the assessment questionnaire. It thus also estimates participant variation by item, as it is possible that some students may have replied very quickly and others very slowly. If any significant relationship was established, we would complement the result with an analysis of Pearson standardized residuals to obtain more specific information about the combinations between teaching methods and learning results that are statistically over-represented.

In all models, significance was calculated with Maximum Likelihood Ratio tests (goodness of fit of two competing statistical models based on the ratio of their likelihoods) and was complemented with the reporting of adjusted R2 values for the model (variance attributed to the fixed effects only).

Finally, to explore if (and if so, to what extent) students' accuracy of responses mirrored parents' expectations about how effective each method was, Welch's variant of the t-test was performed (because this time we do not presume any causality, and because these are unpaired samples of different sizes).

4 Results and Discussion

Study 1: Inferences about the educational process in both parents and children *Headline finding: Parents and children have contrasting expectations about the learning process; more specifically, parents are more likely to be prejudiced against DI, whereas children do not perceive a significant difference between the two teaching methods.*

Before exploring the relationship between the subjective perceptions of the teaching methods under scrutiny (if any), we first checked the extent to which these four perceptions correlate with each other in order to see if they can be combined. Figure 1 shows a correlation matrix of the four variables in question as reported by parents and children respectively. In order to interpret the plots, the darker the blue is and the bigger the dots are, the stronger the association is. Pearson correlation coefficients have been included too for the sake of clarity, where "−1" indicates a perfectly negative linear correlation between two variables, "0" indicates no linear correlation between two variables, and "1" indicates a perfectly positive linear correlation between

two variables (and therefore could be conflated). More specifically, r = 0–0.1 indicates a negligible correlation, r = 0.1–0.39 indicates a weak correlation, r = 0.4–0.69 suggests a moderate correlation, r = 0.7–0.89 points at a strong correlation, and r = 0.9–1 informs of a very strong correlation.

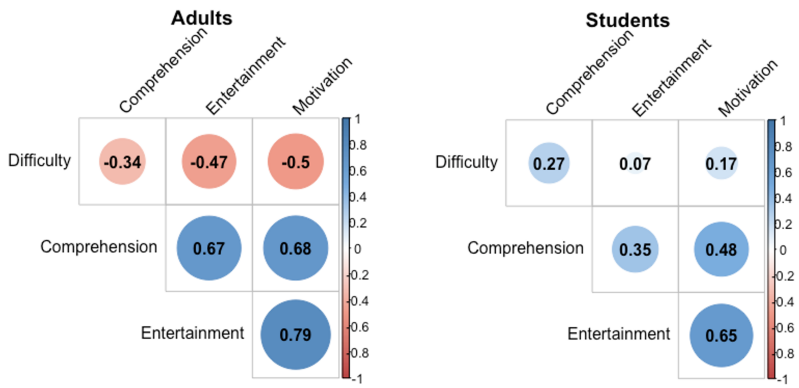


Figure 1. Correlation matrix between perceived difficulty, comprehension, entertainment, and motivation reported by both parents and children who took part in this study.

As can be seen, the most striking difference is that the adult group observes negative relationships between difficulty and the other variables (that is, parents perceive that a difficult learning experience will not lead to a better comprehension of the content, or to fun and motivating learning experiences). This is not the case with the students, who perceive these to be basically independent matters. For the students, only excessively challenging tasks would discourage them from completing the learning process due to a lack of understanding, engagement, and motivation. This latter finding draws attention to the emphasis of DI on the careful design of activities in tracks of increasing difficulty. One of the basic tenets of this method is precisely to provide students with materials that are difficult enough to trigger engagement and curiosity, but not so hard as to cause frustration (Watkins & Slocum, 2003).

However, both parents and children agree that if the lesson experience is fun, it will also encourage further learning (although any causality between entertainment and motivation cannot be established). Overall, the ratings of parents are more extreme than that of children, both in positive and negative correlations. For the children, the only relevant association is between perceived entertainment and motivation, which correlate in a moderate way (r=0.65). This tells us that students feel that they are willing to repeat sessions that they thought to be fun. Arguably one could expect this association to be even stronger, given that we are speaking of 9–10-year-olds; perhaps other aspects should also be regarded as relevant in the learning process. One such aspect could be the perceived comprehension of the task, i.e., the extent to which the students think they understand what they are doing, which also correlates with motivation in a moderate way (r= 0.48). This finding offers a complementary view that suggests that students are also willing to repeat a task if they have properly grasped the contents and purpose (regardless of how entertaining it is, as perceived comprehension and entertainment are only associated in a weak way, r=0.35).

In absence of strong or very strong correlations, we decided to keep the variables separate. See Table 2 for a summary of the mean values reported for ratings given by both parents and students for each variable and by method.

As can be seen, for the student group neither of the methods contributed to making the perception of the task more difficult or easier, since in both DI and PjBL students reported the contents to be easy to grasp (4.4/5). However, students involved in the DI session reported

Table 2. Mean values (over 5) reported for adults' and students' perceptions of difficulty, level of comprehension of the task, degree of entertainment, and degree of motivation, by teaching method.

	DI		PjBL	
	Students	Adults	Students	Adults
Perceived difficulty	4.4	3.31	4.4	2.69
Perceived comprehension	4.5	2.33	4.3	3.67
Perceived entertainment	4.0	1.87	4.2	4.13
Perceived motivation	4.4	2.04	4.1	3.96

higher levels of perceived comprehension (4.5 versus 4.3 in project-based) and motivation (4.4 versus 4.1 in project-based). The only case in which the project-based methodology surpassed the mean rating of DI was in perceived entertainment (4.2 versus 4 in DI). Note, however, that these differences are minimal; in fact, neither of the trends seen for teaching methodologies were statistically significant, at least in a reliable way with the data gathered for this study. That was not the case for the adult group, in which the stark contrast in the ratings provided for PjB and DI respectively were statistically significant in a reliable way (difficulty, $p < .01$; comprehension, $p < .001$; entertainment, $p < .001$; and motivation ($p < .001$). Figure 2 provides a visual overview of the distribution of ratings by both adults and students.

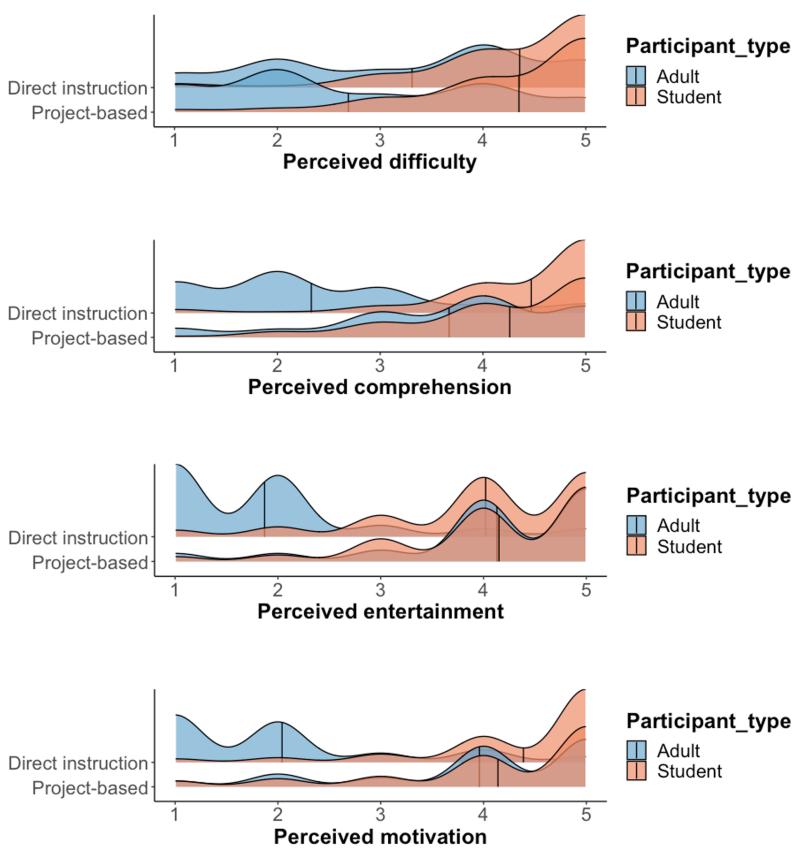


Figure 2. Comparison of adults' and students' ratings for four subjective perceptions of the learning process (vertical black line within the ridges indicate average value).

The mixed linear regression models entered for each subjective perception returned significance for main effects and interaction between methodology and participant type for difficulty ($p < .001$) and comprehension ($p < .001$). This is so because the perceptions of difficulty and comprehension differed greatly for both teaching methods and between both adults and children. For entertainment and motivation, the interaction was also significant, but only because of the significant main effect "methods" ($p < .001$); the type of participant was not significant because both parents and children rated PjB similarly, and the difference mainly came from their divergent perceptions DI.

Until further research is conducted to confirm or discard this association, our interim conclusion is that the teaching method employed in the classroom does not have a strong impact on the way students perceive the learning process, despite the prior beliefs of parents. Whether children find a task difficult or easy to understand, or whether they are engaged enough to repeat the session may rely on other factors, such as the personality of the teacher, their own personal preferences, etc. If anything, what these findings suggest is that the key for a successful learning experience lies in the balanced combination of teaching methods and other aspects such as the teaching materials, the personality of the teacher, students' own preferences, etc., rather than in the type of teaching method, as adults are more likely to believe.

Study 2: Impact of teaching methods on the accuracy of students' responses

Headline finding: DI leads to more accurate responses, whereas PjBL is more likely to produce less accurate answers.

In Study 2 we sought to explore the relationship (if any) between the teaching methodology used and the outcomes of the learning process, in terms of their degree of plausibility in a given context. Figure 3 shows the distribution of expected (recall here that this label combines both prototypically and peripherically correct answers) and unexpected responses. As can be seen, the level of expected responses was overall higher in both teaching methodologies, which speaks in favor of the success of the session. However, the incidence of expected responses was higher after the DI session than after the project-based one (DI: $N = 755$, 54%; PjBL: $N = 637$, 46%). Interestingly, a closer look at the frequency of unexpected responses revealed the greatest difference between both methodologies: it was far greater in the case of PjBL (148, 84%) than in the DI case (28, 16%). A mixed linear regression model confirmed that there was a reliable significant effect of the teaching method on the outcome of the learning process ($p < .01$, $AdjR2 = 0.23$) in a way that was consistent with our data.

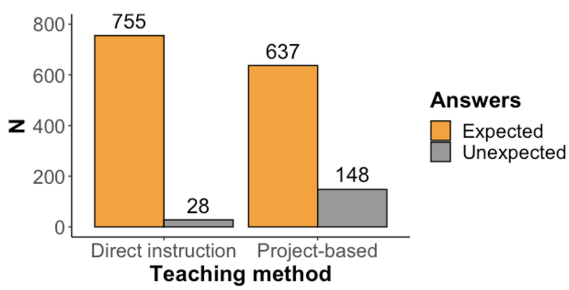


Figure 3. Distribution of expected and unexpected answers by teaching method.

To further explore the specific trends in the data, we conducted an analysis of Pearson standardized residuals. This is a statistical test that shows the type of teaching methodology that is most likely to be associated with each type of learning outcome, in a statistically significant way. The colour code for interpreting the mosaic plot in Figure 4 is as follows: green cells (which represent values over 2, with dark green representing values over 4, and therefore, stronger associations)

mean that there are more observations in the cell than what would be expected if there was a balanced distribution between types of methodology and types of responses (i.e., null model), and therefore constitute an statistically strong association between both variables. Red cells (values under −2) indicate underrepresented combinations, that is, combinations where we found fewer observations than would be expected between a teaching methodology and a given type of answer.

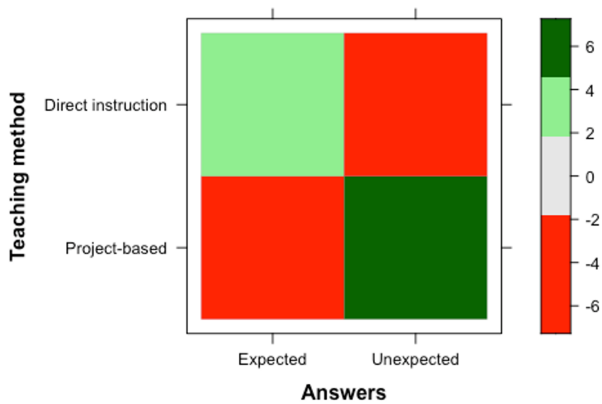


Figure 4. Pearson residuals showing overrepresented and underrepresented combinations between teaching methods and accuracy in responses.

As can be seen in Figure 4, DI is statistically more likely to produce expected answers that are consistent with the instruction and practice undertaken previously, and conversely, unlikely to lead to unexpected answers. The scenario is the opposite for the PjBL method, which is statistically unlikely to produce expected answers consistent with the work carried out previously in the session but, in turn, it is strongly associated with the production of unexpected answers.

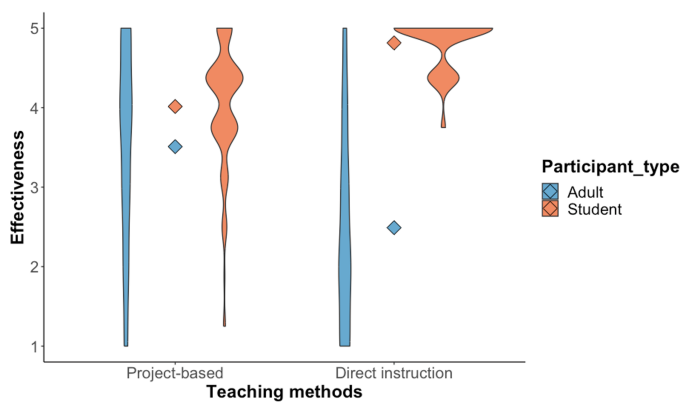


Figure 5. Comparison of adults' expectations of the effectiveness of each teaching method with the actual performance of students in terms of expected answers (the small squares between the violin plots indicate average values).

However, we once again found a stark contrast with parents' expectations about the outcome of the learning process derived from each teaching method (see Figure 5). The 100 students of the PjB condition reported higher acceptable answers ($M = 3.981$, $SD = 0.85$) than what

the 100 adults expected for this teaching method ($M = 3.51$, $SD = 1.27$), which demonstrates a statistically significant difference between both groups, $t(173) = 3.0878$, $p < .01$. The difference was even greater in the DI condition, with students scoring far higher in performance ($M = 4.78$, $SD = 0.42$) than what the adults expected ($M = 2.49$, $SD = 1.26$), in a statistically reliable way ($t(121) = 17.182$, $p < .001$).

Our findings for Study 2 indicate that (1) the role of the teacher guiding the introduction of new concepts may have played a key role in the first stage of the session, in which new concepts are introduced, to consolidate the understanding of the concepts and the task; and suggests that (2) some shortcomings derived from the autonomous work led by students should be compensated by a higher involvement of the teacher-mediator in the project-based method that goes beyond the mere availability to solve questions, in order to ensure more accurate learning outcomes.

5 Conclusions

This paper has reported the results of an experimental study which set out to assess (1) the effects of different teaching methods (DI and PjBL) in the learning outcome of a complex language matter (i.e., speech acts) among primary school students who had received no specific prior teaching on the topic; (2) the impact of these teaching methods in the students' accuracy of responses and perceptions of several aspects of the learning process, including its difficulty, comprehension, engagement, and motivation; and (3) the differences between parents' and students' attitudes towards the educational process motivated by the knowledge-transfer vs knowledge-construction metaphorical framings (here operationalized in terms of two teaching methodologies, DI and PjBL respectively).

We saw in *Study 1* that parents and children have contrasting expectations and perceptions of the learning process; more specifically, parents were more likely to be prejudiced against DI, whereas children did not perceive much difference between the two teaching methods in terms of difficulty, comprehension, entertainment and motivation.

In *Study 2*, the analysis of the data has shown that there was a reliable significant effect of the teaching method on the success of the learning process. Counter to prior beliefs of the parents, DI leads to more accurate responses than PjBL. This suggests that some of the features of this method impact positively on the learning process, among which may be the more active role of the teacher in the classroom, its emphasis in securing students' engagement and participation in the proposed activities, and the organization of the contents in tracks involving a gradual increase in difficulty and students' autonomy. Once the positive impact of DI has been established, it remains to be investigated which specific features of this teaching method have a beneficial effect on learning outcomes.

We also found that the teaching method did not display any statistically significant effect on students' perceptions of the learning process. However, students did report slightly higher levels of perceived comprehension and motivation when involved in DI and higher levels of perceived entertainment when taught according to the PjBL principles. These differences should be further investigated in order to ascertain their relevance in the learning process in relation to other subject matters and diverse educational levels.

Further studies should be carried out with different teaching subject matters and populations so as to examine more deeply the association between comprehension and motivation and their effects on learning outcomes. Nevertheless, the findings arising from the present investigation do point to the need to shift the focus of further research from entertainment (i.e., how much fun students have while learning) to other aspects that seem to have an even more significant influence on the learning process and its outcome.

Finally, the results of this study reveal some interesting framing effects of the metaphors about education under scrutiny. Parents' expectations of the outcome of the learning process, as well as of some of its features (degree of entertainment, difficulty, motivation, and comprehension) arise when

the metaphor EDUCATION IS KNOWLEDGE CONSTRUCTION is at work. These expectations, however, do not match the outcome of the students' performance. Likewise, the negative framing effects that are often associated with the EDUCATION IS KNOWLEDGE TRANSFER metaphor (i.e., worse learning outcomes, less entertaining and motivating, lower comprehension, and higher difficulty) are not supported by the evidence gathered in the study. Further research should continue exploring the framing effects of metaphors in the field of education in two directions: first, by gathering more scientific evidence about the actual outcomes of the two teaching methodologies (both in terms of perceptions and performance) to inform and advise policymakers and practitioners; and second, by exploring the impact of emerging alternative metaphors (see e.g. the rhizome metaphor by which Comier (2008) connects the curriculum with the botanical world) to explore how they contribute to narrowing or widening the gap between perceptions and performance.

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