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Learning With Jigsaw: A Systematic Review Gathering All the Pieces of the Puzzle More Than 40 Years Later

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The jigsaw classroom is a cooperative learning method designed in the late 1970s to improve the academic performance of minority children by reducing intergroup conflict and increasing self-evaluations. Despite its high popularity, the available evidence for the effectiveness of this method seems scant and mixed, with neither meta-analysis nor systematic review. To fill this gap, the authors conducted a systematic review of studies conducted from 1978 through 2022 to assess the effects of jigsaw on both academic performance and psychosocial variables (e.g., intergroup relationships, self-evaluations). Sixty-nine studies met the inclusion criteria. This review revealed the research trends, research gaps, and issues of research integrity of the jigsaw literature. If the results indicate that the jigsaw classroom overall leads to positive *effects, findings vary depending on the academic subjects and psychosocial variables measured. The authors discuss the challenges of jigsaw activities and the limitations of studies reviewed and conclude with practical recommendations in the context of digital education.*

Keywords: collaboration, cooperative learning, desegregation, learning environments, peer interaction/friendship, social class, jigsaw classroom, social interdependence, academic achievement, psychosocial factors

Since the 1980s, cooperative learning emerged as an alternative teaching method to the traditional teacher-guided instruction (also known as lecturing or passive learning) (for meta-analyses, see Johnson et al., 1981; Roseth, Johnson, & Johnson, 2008; Springer, Stanne, & Donovan, 1999). Among the various cooperative learning methods that have been developed, the jigsaw classroom (Aronson et al., 1978) has been largely promoted in the past 40 years. Aronson et al. (1978) developed this noncompetitive peer-learning technique to reduce racial conflict in U.S. schools resulting from desegregation, and improve academic learning for all children. The cornerstone of this method is to split classes into small groups and assign each group member a specific part of the pedagogical content so that group members are dependent on each other to learn and transmit the whole lesson. In doing so, each student becomes, in turn, a learner and a teacher, and is accountable for both their and other group members' success (e.g., Aronson & Patnoe, 2011; Ashman & Gillies, 2003; Johnson & Johnson, 1999).

Jigsaw has grown in popularity for its supposed ability to reduce racial conflict and inequalities among students, to promote better individual academic achievement and to improve students' self-evaluations. For example, as of February 14, 2024, the official website www.jigsaw.org reported that "the site has received 5,164,761 page views, and the Jigsaw Basics document has been downloaded more than 50,000 times." Even recent scholarly articles advertise the benefits of the jigsaw method, aiming at "reviving a powerful positive intervention" (Nalls & Wickerd, 2023). However, rigorous empirical tests are not as numerous as expected, and findings are far from clear, casting doubt on the effectiveness of the jigsaw classroom (e.g., Bratt, 2008; Hornby, 2009; Roseth, Lee, & Saltarelli, 2019). In the present review, we provide the first exhaustive synthesis of 40 years of empirical studies on the jigsaw classroom to clarify the effects of this specific cooperative learning method on both students' academic outcomes and psychosocial variables.

The Jigsaw Classroom: Original Method and Evolutions

As originally developed by Aronson et al. (1978), the jigsaw classroom consists in dividing the content of a lesson among the students (just like a jigsaw puzzle) and structuring students' interactions in small groups following a four-step organization (see Supplemental Figure S1 in the online version of this article). First, the whole classroom is divided into small groups (i.e., called "home groups" or "jigsaw groups"). The academic material (e.g., a scientific paper), which is divided in advance by the teacher into meaningful segments (e.g., introduction, method, results, and discussion), determines the number of students in each group (from four to six). Second, each academic segment (e.g., the introduction) is assigned to only one student in the home group, who must examine their segment individually to become familiar with it. Third, students from different home groups who were assigned the exact same segment (i.e., the introduction) are put together in "expert groups" to master the content and discuss how to teach it adequately to their home groups. This step is designed to promote understanding of the academic content and self-confidence. Fourth, each student goes back in their initial home group to teach the other members about the piece of information previously learned. This part enables knowledge transmission within the group to get the whole lesson. Finally, an individual quiz assesses each student knowledge and understanding of all the segments of the lesson (in our example, the full paper). Even if learning is operating within groups, no collective test or group grade is expected at the end of jigsaw.

Six other versions of the jigsaw classroom have been proposed, with the idea of strengthening some features of the method. In the Jigsaw II version, Slavin (1980) made two major changes. First, the whole content of the lesson is given to each team member (the full paper in our previous example) to create "a less extreme form of specialization" so that students do no depend absolutely on one another (Slavin, 1983, p. 33). Second, a team score is given to every group by summing up individual scores (i.e., reward interdependence) to enhance interdependence among group members and introduce challenging competition between groups. In Jigsaw III, Stahl (1994) implemented a quiz right after the expert phase, which was then corrected by the teacher (for an example, see Holliday, 2002) to ensure that each expert understood their part of the materials before returning to their home group. However, further details are required about this version, which has been hardly used. In Jigsaw IV, Holliday (2000) added an introduction of the content (i.e., teacher's lectures), quizzes after the expert and jigsaw phases to assess understanding of the knowledge, and an optional "reteaching" phase led by the teacher after the individual assessment (for a full description of Jigsaw IV, see Jansoon, Somsook, & Coll, 2008). Later, reverse jigsaw (Hedeen, 2003) and subject jigsaw (Doymus, 2007) were released. Hedeen's (2003) adaptation is quite similar to the original jigsaw (home and expert phases), but the jigsaw phase is replaced with a whole-class presentation, and a "group reporter," chosen by expert group members, must make a report about their own expert topic to the whole class. In contrast, subject jigsaw is more complex, as both "subjects and students are jigsawed" (Doymus, Karacop, & Simsek, 2010). The first part of this activity involves students' working on the same subject (no division of the work, similar subtopic of the lesson), after which they must present their group work to the class. In the second part, new groups are formed: Two or three subjects are brought together (e.g., two students of each subtopic interact), and then, students are asked to make another presentation to the class. Finally, in the third phase, students do whole-class presentations of what they have learned. Consequently, there is no traditional "expert phase" in the subject jigsaw version, and instead the different subtopics of the lesson are gathered. Jigsaw and Jigsaw II are the most used versions of the method, whereas the others (Jigsaw III, Jigsaw IV, reverse jigsaw, and subject jigsaw) seem to have been used only by their developers. In this review, we provide a synthesis of the findings from all of the versions.

Prior Reviews of Jigsaw

As outlined by Roseth et al. (2019), the jigsaw classroom is advocated in many textbooks of social and educational psychology, and the website jigsaw.org reports that it has been used with great success in thousands of classrooms since 1971 to reduce racial conflict among students and promote better academic outcomes. However, the discrepancy between this reputation and the difficulty in finding scientific support is striking. Whereas many reviews and meta-analyses are available on collaborative and cooperative learning methods (e.g., Andrews & Rapp, 2015; Slavin, 2012; Tomcho & Foels, 2012), very few of them included jigsaw studies. In one of the first syntheses on the efficiency of team-learning methods, Sharan (1980) provided a brief review of four studies testing the jigsaw classroom that showed positive effects on academic achievement, social-affective variables, and ethnic relations. Likewise, Slavin (1983) reviewed 46 studies testing the effect of cooperative learning methods on academic achievement. Four jigsaw studies were reported (only one identical to Sharan, 1980), with positive effects for half and null effects for the other half. In an unpublished meta-analysis testing eight different cooperative methods across 154 studies, Johnson, Johnson, and Stanne (2000) reported only 14 studies testing jigsaw. Their results showed a small effect of jigsaw ($d = .29$) on achievement variables compared with competitive learning method (i.e., working alone or with minimal interactions but competing for a reward) and a smaller effect ($d = .13$) compared with individual learning (i.e., working alone or with a minimum of interactions, without any social interdependence or competition for a reward). Furthermore, in the same meta-analysis, when considering effect size of cooperative learning methods compared with competitive and individualistic learning methods, jigsaw ranked among the least efficient relative to seven other cooperative methods. Similarly, empirical support is scarce for benefits of jigsaw with regard to psychosocial variables, such as prejudice reduction or improvement of students' self-esteem, which is at odds with the aims of the method. Obviously, only a limited number of studies of jigsaw has been reviewed, resulting in a lack of knowledge about the effects of this cooperative learning method.

The Present Review

To bridge the gap between popular opinions about the jigsaw classroom and evidence-based research, in the present study we carry out a critical and systematic state-of-the-art review by collating experimental and field studies that have tested the effects of jigsaw on various academic and psychosocial outcomes. Because of extreme statistical heterogeneity among studies, it was not possible to perform a meta-analysis of the studies included. However, it was necessary to summarize for the first time 40 years of research on jigsaw to provide a clear picture of its effects. Knowing whether a popular learning method is effective (and on which outcomes) is important for both researchers and teachers. The aim of the present review was to provide a meticulous analysis of the available research on jigsaw as a learning method and its effects on both academic and psychosocial outcomes, from its development to the present time. We focused on two research questions:

> *Research Question 1*: What are the effects of jigsaw on students' academic achievement in the various subjects studied (i.e., science, technology, engineering, and mathematics [STEM] fields, language and social sciences, and vocational subjects)?
>
> *Research Question 2*: What are the effects of jigsaw on psychosocial variables such as intergroup relationships and self-evaluations?

Method

We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines set for systematic reviews (Moher et al., 2009; Siddaway et al., 2019) and followed Alexander's (2020) methodological guidance. Figure 1 illustrates the literature search and screening process.

Literature Search Strategy

The initial search was conducted from October 2017 to June 2018 and was repeated in December 2022 for the revision of the present review. We used both traditional (Web of Science, ScienceDirect, and PsycInfo) and more encompassing (Education Resources Information Center, Google Scholar) databases for the period from 1976 (the publication date of the first landmark article on jigsaw) to 2022. As searching only for "jigsaw" was not precise enough because of the multiple meanings of the word, we used more specific search terms, such as "jigsaw" combined with (using the Boolean operator AND) "cooperation" or "cooperative learning" and added the following search terms: "interdependence," "achievement," "academic outcomes," "social skills," and "social outcomes." The search was performed with the "all fields" option maintained (i.e., topic, title, keywords, and abstract) and targeted studies published in English and in journal article format.

Inclusion Criteria

In the first round of screening, the main inclusion criterion was the following: Effects of jigsaw were tested. Then, four other inclusion criteria were applied: experimental or quasi-experimental design, control group (between- or within-subjects design), report of quantitative results, and publication in peer-reviewed journals ranked on the Scimago platform.

Study Selection

A total of 8,824 articles were available after the first round of screening, and after checking their references for any citations that did not appear in our electronic searches, 23 further articles were added. After removing 4,764 duplicates across databases, we then refined the results by checking for "jigsaw" in the full text, which left us with 192 articles. To build an exhaustive database of studies covering the widest possible spread of jigsaw effects, the first two authors read and coded all 192 articles to identify dependent variables, experimental designs, nature of the control groups, characteristics of the populations (sample size, age, grade level), locations of the studies, and key findings.

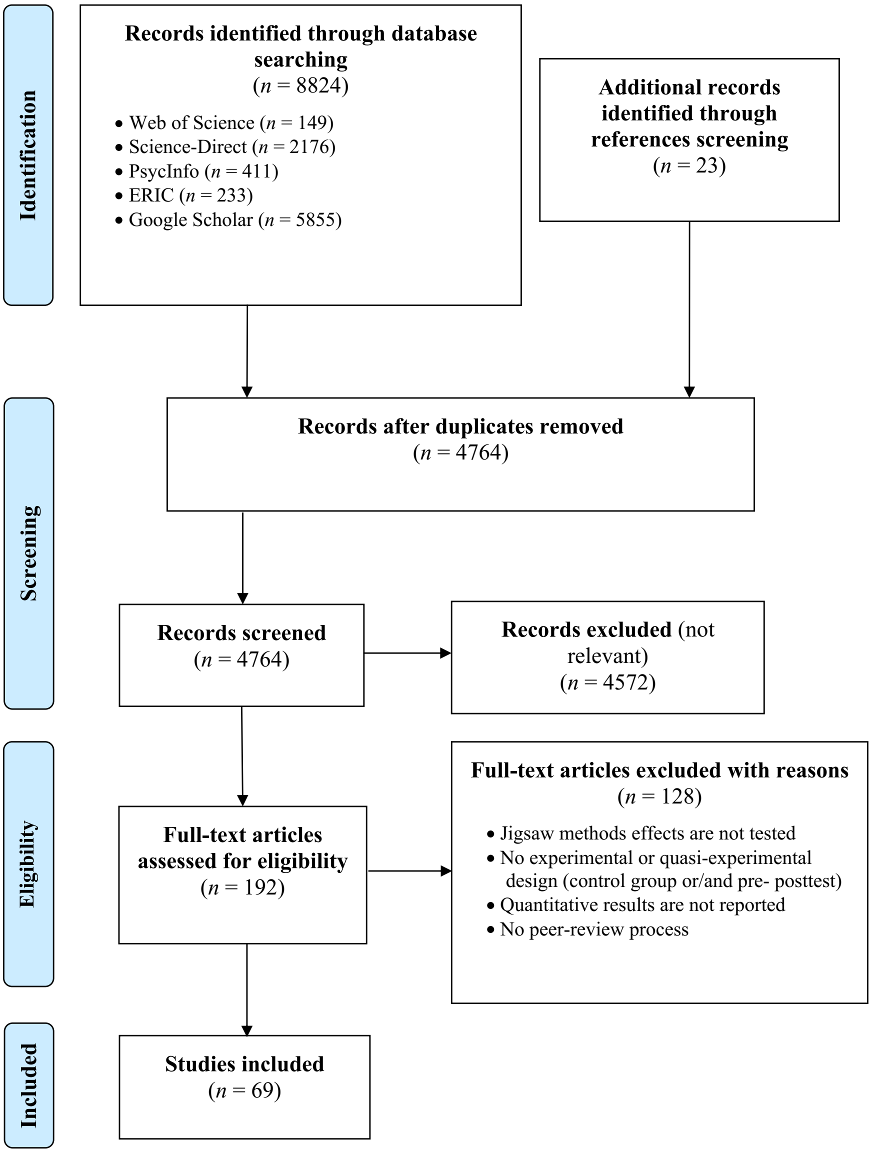

FIGURE 1. *Flowchart of the search and screening process.*

The first glance at the 192 articles revealed major methodological and/or statistical limitations. We had to exclude a great number of articles ($n = 85$; see the Supplemental Materials for references) that did not follow our inclusion criteria (with many studies presenting one or more limitations). Among the 85 excluded studies, 70 were qualified as "report studies": devoted to the teaching community and not supporting any experimental approach. Although such publications were aimed at introducing the jigsaw method to educational practitioners, the reader should be warned about several methodological flaws. A number of studies (n = 37) were also conducted in an unorthodox fashion (e.g., Demir, 2012), including neither a control condition (use of other learning methods) nor a baseline (pretest or past grades). Other studies (n = 48) did not provide any statistical analyses (e.g., Kardaleska, 2013) or reported aggregated scores from the jigsaw condition with other cooperative learning conditions to compare with traditional teaching instruction, making it impossible to draw conclusions about the efficacy of jigsaw (e.g., Goudas & Magotsiou, 2009; Gull & Shehzad, 2015; Slavin & Karweit, 1981). Finally, some studies (n = 11) introduced such important changes to the jigsaw method (e.g., lack of an expert group, possibility to come back to the expert group, no pedagogical content division), such that it could no longer be considered as a jigsaw classroom (e.g., Gambari & Yussuf, 2017; Jones, Graham, & Schaller, 2012). These articles were excluded from the present review (references are available in the Supplemental Materials). The final criterion (publication in peer-reviewed journals ranked on the Scimago platform) led us to exclude 43 articles. This resulted in a final sample of 64 articles.

Data Analysis

To achieve a comprehensive understanding of the effects of jigsaw on academic outcomes (Research Question 1) and psychosocial variables (Research Question 2), we reviewed findings according to the population (elementary, middle school, high school, or undergraduate students), jigsaw version, and comparison condition (control group, pretest-posttest) that were used. A distinction between immediate posttest and delayed posttest was made when the performance test was measured right after learning or after a delay, varying from a few weeks to 1 year. Two specific elements must be detailed in this review in considering the duration of each study: (a) the total period covered by the procedure, from a single shot (e.g., one class session) to a full year of implementation of the jigsaw method and its control(s), and (b) the length of each class session. For instance, a reported duration of one trimester, 4 × 50 minutes/week, means that the students took four class sessions of 50 minutes/week during one full trimester. Findings are explained according to authors' argumentation. Additional details are provided for studies with specific contributions to the field (e.g., the role of the expert phase, comparison with other cooperative methods).

Results

Study Characteristics

In total, 69 studies (64 articles) were included in this review. Most studies came from educational sciences (58%) or psychology (32%) departments, and the remainder were spread between medicine and language departments. Studies originated predominantly in Eastern countries, with 20 articles from Turkey, and North America, with 15 articles from the United States. Most of studies assessed academic achievement (n = 59), 33 of which also measured psychosocial factors, and 10 studies tested exclusively for psychosocial factors. Only two articles conducted a series of studies to replicate their own findings.

Outcomes with the jigsaw classroom were compared with traditional learning methods ($n = 54$), other cooperative learning with or without resource interdependence ($n = 11$), and modified jigsaw scripts ($n = 6$), and two studies made comparisons between jigsaw experts and novices. Traditional learning methods are teaching-as-usual class configuration, in which students learn individually, with no work in small groups, as teacher-centered classes, lectures, or animation using computers. Cooperative learning methods include student-centered methods based on group work and structured with or without resource interdependence. Modified jigsaw scripts include learning environments inspired by jigsaw techniques that introduce one or many changes from the original version. See Supplemental Table S1 for a description of the learning methods with which jigsaw was compared.

Table 1 provides an overview of the 69 included studies and summarizes characteristics of the population (sample size, age, grade, and country), experimental design (pretest-posttest, duration of the implementation, version of jigsaw, type of control condition), main dependent variables, and their associated results on academic performances and/or psychosocial variables. Table 2 reports the occurrence of positive, negative, and null effects of the jigsaw classroom (note that effects resulting from comparisons between two versions of jigsaw do not appear in Table 2).

Jigsaw Effects on Academic Achievement

Given the diversity of academic fields in which jigsaw was tested, the first research question is addressed in three distinct parts. The first part describes the effects of jigsaw in STEM fields ($n = 32$ studies), the second exposes those in language and social sciences ($n = 21$ studies), and the third refers to vocational fields ($n = 8$ studies).

STEM Achievement

Thirty-two studies tested performance in physics ($n = 6$), chemistry ($n = 7$), biology ($n = 9$), mathematics ($n = 9$), and technology ($n = 1$). A mixed pattern of results emerged (see Table 2), with 19 positive effects, 5 negative effects, and 10 null effects according to their respective control groups (i.e., 4 studies yielded mixed results depending on whether the jigsaw method was compared with a cooperative or a traditional learning method).

Chemistry. Among the seven studies conducted in this field, with sample sizes varying from 38 to 122 participants, all showed beneficial effects of the original jigsaw (Cerón-García et al. 2021; Doymus et al., 2010; Karacop & Doymus, 2013; Tarhan & Acar Sesen, 2012; Tarhan et al., 2013) and subject jigsaw version (Doymus, 2007, 2008) on students' performance compared with a traditional learning group. However, compared with an animation group (see Supplemental Table S1), jigsaw appeared to be less efficient. This was the case in the study of Doymus et al. (2010), who observed that animation group outperformed both subject jig-

TABLE 1

Methodological details and results of studies included in this review

Subject areas	Study	Participants	Experimental design	Measures (a) Academic performance (b) Socioaffective measures	Results: academic performance	Results: psychosocial measures
STEM fields						
Physics	Berger & Hänze (2009)	n = 286; 12th grade; age = 17–18; Germany	Quasi-experimental; crossover design; pre-post; duration: 2 sessions (3/4 hours); 2 conditions: jigsaw vs. CR	(a) Open-ended questions (b) Intrinsic motivation and basic needs (social relatedness, experience of competence and autonomy)	Interaction effect between condition and subject topics	No difference between conditions on social relatedness and intrinsic motivation; jigsaw was favorable for experience of competence, but not for feeling of autonomy
	Berger & Hänze (2015)	n = 129; 12th grade; age = 17–18; Germany	Quasi-experimental; crossover design; pre-post; duration: 2 sessions (3/4 hours); 2 conditions: jigsaw experts vs. jigsaw novices	(a) Open-ended questions (b) Intrinsic motivation; cognitive demand; teaching quality	Higher scores for jigsaw experts than jigsaw novices; effect of the quality of expert students' instruction	—
	Hänze & Berger (2007)	n = 137; 12th grade; age = 17–18; Germany	Quasi-experimental; pre-post; duration: 2 sessions (3/4 hours); 2 conditions: jigsaw vs. traditional class	(a) Open-ended questions (b) Academic self-concept; academic goal orientation	No difference between conditions on academic performance	With jigsaw: increased experience of competence, which improved academic performance; low-self-concept students improved performance; girls reported a greater feeling of competence
	Koç et al. (2010)	n = 106; undergraduate students; age = 19; Turkey	Quasi-experimental; pre-post; duration: 4 weeks (4 hours/week); 3 conditions: subject jigsaw vs. group investigation vs. traditional class	Multiple-choice questions	Both group investigation and subject jigsaw improved students' achievement; jigsaw condition was more successful in reading and interpreting graphs	—
	Ural, Ercan, & Gençoğlan (2017)	n = 49; 6th grade; age = 12; Turkey	Experimental; pre-post; duration: 6 weeks; 2 conditions: jigsaw vs. traditional class	(a) Multiple-choice questions (b) Science learning motivation; science class attitudes; attitudes toward jigsaw	Jigsaw improved students' achievement	Higher intrinsic motivation and positive views of jigsaw
	Stanczak et al. (2021) (Study 3A)	n = 110; 6th graders; age = NA; France	Experimental; duration: 2-hour session; jigsaw vs. individual learning	Multiple-choice questions; problem-solving test	No difference between conditions	—
Chemistry	Cerón-García et al. (2021)	n = 68; undergraduate students; age = NA; Spain	Experimental; duration: 2 weeks; 2 conditions: jigsaw + Mathcad vs. traditional class + Mathcad	(a) Average score (b) Self-assessment questionnaire; attitudes toward jigsaw	Jigsaw outperformed traditional condition	Students reported positive views of jigsaw
	Doymus (2007)	n = 108; undergraduate students; age = NA; Turkey	Experimental; pre-post; duration: 3 weeks (2 hours/week); 2 conditions: subject jigsaw vs. traditional class	Multiple-choice questions	Subject jigsaw improved students' achievement	—
	Doymus (2008)	n = 68; undergraduate students; age = NA; Turkey	Experimental; posttest; duration: 5 weeks (NA); 2 conditions: subject jigsaw vs. traditional class	Multiple-choice and open-ended questions	Subject jigsaw improved students' performance	—
	Doymus et al. (2010)	n = 122; undergraduate students; age = NA; Turkey	Experimental; pre-post; duration: 5 weeks (NA); 3 conditions: subject jigsaw vs. AG vs. traditional class	Open-ended questions	AG outperformed jigsaw condition	—

(continued)

Table 1. (continued)

Subject areas	Study	Participants	Experimental design	Measures (a) Academic performance (b) Socioaffective measures	Results: academic performance	Results: psychosocial measures
	Karacop & Doymus (2013)	n = 115; undergraduate students; age = NA; Turkey	Quasi-experimental; posttest; duration: 5 weeks (6 × 2 hours sessions); 3 conditions: subject jigsaw vs. AG vs. traditional class	Multiple-choice and open-ended questions	AG outperformed subject jigsaw, and subject jigsaw outperformed traditional class in conceptual understanding	—
	Tarhan & Acar Sesen (2012)	n = 38; undergraduate students; age = 18–19; Turkey	Quasi-experimental; pre-post; duration: 1 session (NA); 2 conditions: jigsaw vs. traditional class	(a) Multiple-choice and open-ended questions (b) Semistructured interviews	Jigsaw improved students' conceptual understanding	Students reported positive views of jigsaw
	Tarhan et al. (2013)	n = 61; 6th grade; age = 12; Turkey	Quasi-experimental; pre-post; duration: 2 weeks (4 hours/week); 2 conditions: jigsaw vs. traditional class	(a) Multiple-choice questions (b) Semistructured interviews	Jigsaw improved students' achievement	Students reported positive views of jigsaw
Biology	Lazarowitz, Hertz-Lazarowitz, & Baird (1994)	n = 120; 11th and 12th grades; age = 16–18; United States	Quasi-experimental; pre-post; duration: 5 weeks (NA); 2 conditions: jigsaw vs. traditional class	(a) Multiple questions; essay. (b) Self-esteem; attitudes toward biology; friendships and classroom climate	Jigsaw improved students' performance on multiple-choice questions; no difference between conditions on the essay	Increase of self-esteem and number of friends; no effect on classroom climate neither on attitudes toward biology
	Roseth et al. (2019)	n = 258; undergraduate students; age = 18–24; United States	Experimental; pre-post; duration: 14 weeks (8 × 75 minutes); 2 conditions: jigsaw vs. traditional class	(b) Quizzes (b) Cooperation, motivation and sociocognitive conflict regulation	Jigsaw improved students' achievement scores	Increase over time in academic achievement was associated with an increase in epistemic regulation but decrease in relational regulation
	Slish (2005)	n = 52; undergraduate students; age = NA; United States	Quasi-experimental; pre-post; duration: 1 full semester (NA); 2 conditions: jigsaw vs. traditional class	Multiple-choice questions and essays	No difference between conditions	—
	Walker & Crogan (1998)	n = 103; 4th to 6th grades; age = 9–11; Australia	Quasi-experimental; pre-post; duration: 3–4 weeks (60–90 minutes per day/week); 3 conditions: jigsaw vs. cooperative learning vs. traditional class	(a) Multiple-choice questions (b) Self-esteem; sociometric class survey; social distance; stereotypes	Jigsaw improved students' achievement	With jigsaw: increase of self-esteem and liking of school; liking of in-group and out-group peers; reduction of social distance and prejudice
	Stanczak et al. (2021) (Study 2)	n = 313; 6th graders; age = 11; France	Experimental; duration: 2-hour session; jigsaw vs. individual learning	Multiple-choice questions; problem-solving test	No difference between conditions	—
	Stanczak et al. (2021) (Study 3B)	n = 74; 6th graders; age = NA; France	Experimental; duration: 12 × 90-minute sessions; jigsaw vs. traditional class	Multiple-choice questions; problem-solving tests; true-or-false tests	No difference between conditions	—
	Stanczak et al. (2021) (Study 3C)	n = 101; 6th graders; age = NA; France	Experimental; duration: 12 × 90-minute sessions; jigsaw vs. traditional class	Multiple-choice questions; problem-solving tests; true-or-false tests	No difference between conditions	—
	Mutlu (2018)	n = 52; undergraduate students; age = NA; Turkey	Quasi-experimental; pre-post; duration: 9 weeks (NA); 2 conditions: jigsaw vs. TGT	Open-ended questions	Jigsaw outperformed TGT	—

(continued)

Table 1. (continued)

Subject areas	Study	Participants	Experimental design	Measures (a) Academic performance (b) Socioaffective measures	Results: academic performance	Results: psychosocial measures
	Moreno (2009)	*n* = 87; undergraduate students; age = 24; United States	Experimental; pre-post; duration: 1 session (60 minutes); 3 conditions: jigsaw vs. cooperative learning vs. individual learning	(a) Retention and problem solving (b) Learning perception; cognitive load	No difference between conditions on the retention test; control conditions outperformed jigsaw on problem-solving test; higher cognitive load with jigsaw in comparison with individual learning	—
Mathematics	Artut & Tarim (2007)	*n* = 81; PTs; age = NA; Turkey	Quasi-experimental; pre-post; duration: 9 weeks (NA); 2 conditions: Jigsaw II vs. traditional class	(a) Multiple-choice questions (b) Attitudes toward jigsaw	Jigsaw II improved PTs achievement; no difference between low vs. medium vs. high PTs achievers	Students reported positive views of jigsaw & higher level of responsibility; 53% reported lack of comprehension of the topics
	Deiglmayr & Schalk (2015)	*n* = 78; undergraduate students; age = 24; Switzerland	Experimental; pre-post; duration: 1 session (2.5 hours); 2 conditions: jigsaw weak-knowledge interdependence vs. strong-knowledge interdependence	Application test and transfer task (problem solving)	Jigsaw weak-knowledge interdependence condition improved low prior knowledge learners' transfer performance	—
	Stanczak et al. (2021) (Study 1)	*n* = 252; 6th graders; age = 11, 14; France	Experimental; duration: 2-hour session; jigsaw vs. individual learning	Multiple-choice questions; problem-solving test	No difference between conditions	—
Mathematics and reading	Moskowitz et al. (1983)	*n* = 261; 5th and 6th grades; age = 10–11; United States	Experimental; pre-post; duration: 1 year (2 hours/week); 2 conditions: jigsaw vs. traditional class	(a) Stanford Achievement Test (b) Affective teaching climate; classroom climate; attitudes toward school; academic and social self-esteem; attitudes toward peers; locus of control	No difference between conditions on achievement	No effect on school attitudes nor on self-concept; classroom climate was reported as less competitive
	Moskowitz et al. (1985)	*n* = 384; 5th grade; age = 10; United States	Experimental; pre-post; duration: 24 weeks (2 hours/week); 2 conditions: jigsaw vs. traditional class	(a) Stanford Achievement Test (b) Self-esteem	Traditional class outperformed jigsaw in mathematics; no difference between conditions on reading	With jigsaw: girls showed greater self-esteem; boys showed lower social self-esteem
Statistics	Perkins & Saris (2001)	*n* = 55; undergraduate students; age = NA; United States	Quasi-experimental; within-subject design; pre-post; duration: 1 year (NA)	(a) Worksheets and conceptual test (b) Attitudes toward jigsaw	Jigsaw improved students' performance	Students reported positive views of jigsaw
	Kritpracha et al. (2018)	*n* = 45; undergraduate students; age = NA; Thailand	Quasi-experimental; within-subject design; pre-post; duration: 16 weeks; jigsaw	Multiple-choice questions; learning questionnaire	Jigsaw improved students' performance	Self-directed learning strategies increased
Geometry and astronomy	Souvignier & Kronenberger (2007)	*n* = 208; 3rd grade; age = 8; Germany	Quasi-experimental; pre-post; delayed posttest; duration: 6 weeks (6 × 45 minutes); 3 conditions: jigsaw vs. jigsaw + questioning training vs. traditional class	Open-ended questions	In math units: no difference between conditions; in astronomy: traditional class outperformed jigsaw; no difference between conditions on delayed retention tests	—

(continued)

Table 1. (continued)

Subject areas	Study	Participants	Experimental design	Measures (a) Academic performance (b) Socioaffective measures	Results: academic performance	Results: psychosocial measures
Mathematics	Tran & Lewis (2012)	n = 80; undergraduate students; age = 22; Vietnam	Quasi-experimental; pre-post; delayed posttest; duration: 7 weeks (6 × 150 minutes); 2 conditions: jigsaw vs. traditional class	(a) Multiple-choice questions (b) Attitudes toward jigsaw	Jigsaw had positive effects on both immediate and delayed tests	Students reported positive views of jigsaw
Technology	van Dijk, Eysink, & de Jong (2020)	n = 136; 5th and 6th graders; age = 11; the Netherlands	Quasi-experimental; pre-post; duration: 7 weeks; 2 conditions: jigsaw + script supported vs. jigsaw + script unsupported	Open-ended questions; open recall test; video recordings	(a) Jigsaw + script enhanced domain-related knowledge (b) Low ability students benefited the most from the jigsaw + script	—
Language and social sciences						
Grammar	Arslan (2016)	n = 56; 8th grade; age = 13; Turkey	Quasi-experimental; pre-post; duration: 3 weeks (3 × 3 hours); 2 conditions: jigsaw vs. traditional class	(a) Multiple-choice questions (b) Attitudes toward course	No difference between conditions on achievement	No effect on attitudes toward course
Literature	Göçer (2010)	n = 60; 11th grade; age = 16–17; Turkey	Experimental; pre-post; duration: 3 weeks (NA); 2 conditions: jigsaw vs. traditional class	(a) Open-ended questions (b) Interviews about jigsaw	Jigsaw improved teaching of literary genres	Students and teachers reported positive views of jigsaw
	Law (2011)	n = 279; 5th grade; age = 10; China	Quasi-experimental; pre-post; delayed posttest; duration: 5 sessions (5 × 5 hours), 3 conditions: jigsaw vs. drama group vs. traditional class	(a) Reading comprehension; written expression (b) Achievement goals; autonomy; attitudes toward jigsaw	Jigsaw improved students' reading comprehension on both posttest and delayed test compared with drama and traditional conditions	Jigsaw students had higher mastery goals than traditional class; no effect on other goals; no effect on autonomy
	Şahin (2010)	n = 80; undergraduate students; age = NA; Turkey	Experimental; pre-post; delayed posttest; duration: 6 weeks (6 × 4 hours); 2 conditions: Jigsaw II vs. traditional class	(a) Open-ended questions (b) Attitudes toward written expression; attitudes toward jigsaw	Jigsaw II improved knowledge about written expression in both posttest and delayed test	Students reported positive views of jigsaw and positive attitudes toward written expression
	Şahin (2011)	n = 71; 6th grade; age = 11; Turkey	Experimental; pre-post; delayed posttest; duration: 6 weeks; 2 conditions: Jigsaw III vs. traditional class	(a) Open-ended questions (b) Attitudes toward jigsaw	Jigsaw III improved students' knowledge about written expression in both posttest and delayed test	Students reported positive views of jigsaw
English (EFL)	Evcim & İpek (2013)	n = 48; undergraduate students; age = NA; Turkey	Experimental; posttest; duration: 1 week (3 sessions); 2 conditions: Jigsaw II vs. traditional class	Multiple-choice questions	Jigsaw II improved students' achievement	—
	Ghaith & El-Malak (2004)	n = 48; undergraduate students; age = 17–19; Lebanon	Experimental; pre-post; duration: 5 weeks (3 × 55 minutes/week); 2 conditions: Jigsaw II vs. traditional class	Literal and higher order comprehension questions	Jigsaw II improved EFL students' higher order reading comprehension in English	—
	Gömleksiz (2007)	n = 66; undergraduate students; age = 21; Turkey	Quasi-experimental; pre-post, delayed posttest; duration: 4 weeks (2 hours/week); 2 conditions: Jigsaw II vs. traditional class	(a) Vocabulary (b) Attitudes toward English	Jigsaw II improved students' performance in both posttest and delayed test	Jigsaw students reported positive views toward learning English and better interactions
	Rimani Nikou, Alavinia, & Karimzadeh (2013)	n = 32; students from English language institute; age = 14–18; Iran	Experimental; pre-post; duration: 6 weeks (3 sessions/week); 2 conditions: jigsaw vs. traditional class	Oral proficiency and speaking comprehension	Jigsaw improved learners' oral proficiency and speaking skills	—

(continued)

Table 1. (continued)

Subject areas	Study	Participants	Experimental design	Measures (a) Academic performance (b) Socioaffective measures	Results: academic performance	Results: psychosocial measures
	Shaaban (2006)	n = 44; 5th grade; age = 11–12; Lebanon	Quasi-experimental; posttest; duration: 8 weeks (10 × 60 minutes/week); 2 conditions: Jigsaw II vs. traditional class	(a) Multiple-choice questions (b) Motivation to read	No difference between conditions on vocabulary acquisition and reading comprehension	Jigsaw II increased EFL learners' perceptions of the value of reading, reading self-concept, and overall motivation to read
Economics	Basyah, Muslem, & Usman (2018)	n = 60; 11th grade; age = 16–17; Indonesia	Quasi-experimental; pre-post; duration: 14 weeks (1 hour/week); 2 conditions: jigsaw vs. traditional class	Essays	Jigsaw improved students' performance	—
Cognitive psychology	Crone & Portillo (2013)	n = 70; undergraduate students, age = 26; United States	Quasi-experimental; pre-post; duration: 1 semester (75 minutes); 3 conditions: jigsaw full schedule vs. jigsaw reduced schedule vs. traditional class	(a) Final exam score (b) Academic self-efficacy	No difference between the three conditions in final scores	Jigsaw conditions reported more confidence in their ability to teach; jigsaw full-time schedule increased both self-efficacy and self-esteem
Social psychology	Nolan et al. (2018)	n = 126; undergraduate students; age = NA; United States	Quasi-experimental; Within-subject design; delayed posttest; duration: NA; jigsaw	Quiz; final grade	Students prefer and perform better the assigned jigsaw topic	—
Education	Hornby (2009)	n = 44; undergraduate students; age = 22; England	Experimental; pre-post; duration: 1 session (2 hours); 2 conditions: workshop with Jigsaw II vs. workshop	(a) Multiple-choice questions (b) Attitude toward learning strategies	Jigsaw II improved students' performance	Students reported positive views of jigsaw and the workshop
	Kilic (2008)	n = 80; undergraduate students; age = NA; Turkey	Experimental; pre-post; duration: 3 weeks (full weeks) 2 conditions: jigsaw vs. traditional class	Multiple-choice questions	Jigsaw improved students' achievement	—
Geography	Huang et al. (2014)	n = 63; undergraduate students; age = NA; Taiwan	Experimental; pre-post; duration: 1 session (3 hours); 2 conditions: jigsaw vs. traditional class	(a) Multiple-choice questions (b) Attitudes toward jigsaw	Jigsaw improved low- and medium-achieving students' performance	High achievers preferred individual learning, whereas medium and low achievers preferred jigsaw
	Ziegler (1981)	n = 146; 5–6th grades; age = 10–11; Canada	Quasi-experimental; posttest; duration: 8 weeks (120 minutes/week); 2 conditions: jigsaw vs. traditional class	(a) Open-ended questions (b) Sociometric survey; attitude toward social diversity	Jigsaw improved students' achievement	Increase of cross-ethnic friendships
History	Lucker et al. (1976)	n = 303; 5th and 6th grades; age = 10–11; United States	Quasi-experimental; field study; pre-post; duration: 2 weeks (45 minutes every day/week); 2 conditions: jigsaw vs. traditional class	Open-ended questions	Improvement in performance with jigsaw was linked to improvement of minorities' performance	—
	Yapici (2016)	n = 53; 7th grade; age = 12; Turkey	Quasi-experimental; pre-post; delayed posttest; duration: 3 weeks (3 hours/week); 2 conditions: jigsaw vs. traditional class	(a) Multiple-choice questions and retention tests (b) Attitude toward jigsaw	Jigsaw improved students' performance in social sciences in both posttest and delayed retention tests	Students reported positive views of jigsaw
Vocational						
Medicine	Desforges et al. (1991)	n = 95; undergraduate students; age = NA; United States	Experimental; posttest; duration: 1 session (2 hours); 3 conditions: jigsaw vs. cooperative learning vs. traditional class	(a) Recall test (b) Attitudes toward a minority	No difference between the three conditions on students' recall test	Jigsaw reduced prejudice: decrease of negative attitudes toward former mental patients

(continued)

Table 1. (continued)

Subject areas	Study	Participants	Experimental design	Measures (a) Academic performance (b) Socioaffective measures	Results: academic performance	Results: psychosocial measures
Nursing	Lai & Wu (2006)	n = 99; 4th-year nursing students; age = NA; Taiwan	Quasi-experimental; pre-post; duration: 3 weeks (3 hours/week); 2 conditions: jigsaw on handheld (PDA) vs. jigsaw classroom (non-PDA)	(a) Drawing concept maps (b) Attitudes toward jigsaw; nature of students' interactions; attitudes toward learning activities; observation of interactive behaviors; students' interactions perceptions	Jigsaw PDA had better map conceptions than original jigsaw classroom (non-PDA)	Jigsaw PDA increased the perception of social interactions between students
Video games	Nebel et al. (2017)	n = 56; high school students; age = 17; Germany	Experimental; pre-post; duration: 1 session (90 minutes); 2 conditions : jigsaw vs. Voluntary cooperation	Overall speaking time and explanations; cognitive load; efficiency learning; gaming performance; reading and elaboration	Jigsaw increased performance that in turns, enhanced efficiency learning; mental effort was more important with jigsaw but did not decrease performance; no effect on overall speaking time	—
Computer sciences	Parsazadeh, Ali, & Rezaei (2018)	n = 67; 2nd-year undergraduate students; age = NA; Malaysia	Quasi-experimental; pre-post; duration: 1 session (180 minutes); 2 conditions: jigsaw vs. traditional class	Multiple-choice questions and essay	Jigsaw (as a mobile application) improved students skills in evaluation of websites and their knowledge about cybersecurity	—
Dental education	Sagsoz et al. (2017)	n = 50; 3rd-year odontology students; age = NA; Turkey	Experimental; pre-post; delayed posttest; duration: 3 weeks (NA); 2 conditions: jigsaw vs. traditional class	Multiple-choice questions	No difference between conditions on performance; jigsaw condition had positive effects on delayed retention test	—
	Suárez-Cunqueiro et al. (2017)	n = 109; 5th-year odontology students; age = NA; Spain	Quasi-experimental; posttest; duration: 3 months (NA); jigsaw vs. traditional class	(a) Multiple-choice and open-ended questions; resolution of clinical cases and continuous evaluation of the clinical practice (b) Attitudes toward jigsaw	Jigsaw improved students' achievement in both academic and practical education	With jigsaw: higher attendance to final exam; students reported positive views of jigsaw and declared it was more effortful than usual
Pharmacy	Wilson et al. (2017)	n = 88; undergraduate pharmacy students; age = 24; United States	Quasi-experimental; pre-post; duration: 1 semester (NA); 2 conditions: jigsaw vs. traditional class	(a) Multiple-choice questions (b) Attitudes toward jigsaw	No difference between conditions	Students favored the jigsaw method over traditional lecture
Design	Zacharia, Xenofontos, & Manoli (2011)	n = 38; 7th grade; age = 14; Cyprus	Quasi-experimental; pre-post; duration: 6 sessions (90 minutes); 2 conditions: jigsaw vs. cooperative group	(a) Closed- and open-ended questions (b) Social interactions	No difference between conditions	Mistrust issues in the jigsaw condition
Psychosocial measures only						
Social sciences and mathematics	Blaney et al. (1977)	n = 304; 5th grade; age = 10; United States	Quasi-experimental; pre-post; duration: 6 weeks (3 × 45 minutes/week); 2 conditions: jigsaw vs. traditional class	Peer liking; liking of school; self-esteem; sociometric scale	—	Jigsaw improved self-esteem, liking of school, and liking of classmates
NA	Bratt (2008)	Study I: n = 68; 6th grade; age = 11; Study II: n = 164; 8th to 10th grade; age = 14; Norway	Quasi-experimental; pre-post; duration Study I: 7 weeks (2 hours/week); duration Study II: 8 weeks (1 or 2 hours/week); 2 conditions: jigsaw vs. traditional class	Studies I and II: intergroup attitudes; attitudes toward classmates and school; empathy; intergroup friendship	—	No effect on intergroup relationships; decrease of empathy levels

(continued)

Table 1. (continued)

Subject areas	Study	Participants	Experimental design	Measures (a) Academic performance (b) Socioaffective measures	Results: academic performance	Results: psychosocial measures
Social sciences	Bridgeman (1981)	n = 120; 5th grade; age = 10; United States	Quasi-experimental; pre-post; duration: 8 weeks (NA); 3 conditions: jigsaw vs. innovative learning vs. traditional class	Perspective taking; moral dilemmas	—	Increase of role taking perspective; no effects on moral reasoning
Mathematics and French	Darnon, Buchs, & Desbar (2012)	n = 33; vocational training students; age = 18; France	Experimental; pre-post; duration: 4 sessions (4 × 2 hours); 2 conditions: jigsaw vs. traditional class	Self-efficacy	—	Increase of academic self-efficacy in mathematics and reading
Computer sciences	Huang, Huang, & Yu (2011)	n = 115; undergraduate students; age = NA; Taiwan	Experimental; pre-post; duration: 1 semester (3 hours/week); 2 conditions: blog-based jigsaw vs. jigsaw	Perceptions of social interactions; attitudes toward jigsaw	—	Increase of social interactions and positive views of jigsaw
Nursing	Sanaie et al., 2019	n = 94; undergraduate students; age = 20; Iran	Quasi-experimental; pre-post; duration: 17 two-hour sessions; 2 conditions: jigsaw vs. traditional class	Self-regulation; academic strategies; extrinsic motivation; intrinsic motivation	—	Jigsaw increased both self-regulation and academic motivation
NA	Santos Rego & Moledo (2005)	n = 250; secondary school students; age = 12–14; Spain	Quasi-experimental; pre-post; duration: 1 year; 2 conditions: jigsaw vs. control (no further details)	Intercultural attitudes	—	No difference in cultural attitudes
Geometry	Şengül & Katranci (2014)	n = 33; 7th grade; age = NA; Turkey	Experimental; within-subject design; pre-post; duration: 1 session (4 hours); jigsaw	Attitudes toward mathematics	—	No difference in attitudes toward mathematics
Biology	Theobald et al. (2017)	n = 684; From 1st- to 5th-year undergraduate students; age = 18–24; United States	Quasi-experimental; pre-post; duration: 1 trimester (4 × 50 minutes/week); 2 conditions: jigsaw vs. single group activity	Perception of group dynamics	—	Students were less likely to agree that someone dominated their group; jigsaw can help reduce inequality among groups

Note. AG = animation group; CR = cyclical rotation; EFL = English as a foreign language; NA = not available; PDA = personal digital assistant; PT = prospective elementary school teacher; STEM = science, technology, engineering, and mathematics; TGT = team game tournament.

TABLE 2.

Occurrence of positive, negative, and null effects of the jigsaw classroom on academic performance and psychosocial variables

Outcomes	Positive effects	Negative effects	Null effects	Total effects
Academic performance				
STEM fields				
Chemistry	7	2	0	9
Biology	3	1	6	10
Physics	5	0	1	6
Mathematics	4	2	3	9
Total number of effects in STEM	19 (55%)	5 (14%)	10 (29%)	34
Language and social sciences				
Language arts	4	0	3	7
English as a foreign language	4	0	1	5
Social sciences	6	0	1	7
Total number of effects in language and social sciences	14 (73%)	0	5 (33%)	19
Vocational achievement	3 (42%)	1 (14%)	3 (42%)	7
Total number of effects for all academic fields	36 (60%)	6 (10%)	18 (30%)	60
Psychosocial variables				
Intergroup relationships	5	1	3	9
Self-evaluations	8	1	3	12
Motivation	6	0	2	8
Attitudes toward jigsaw	15	1	0	16
Attitudes toward subject topic	3	0	3	6
Classroom climate	1	0	1	2
Total number of effects for psychosocial variables	38 (53%)	3 (5%)	12 (23%)	53
Total number of effects for all outcomes	74 (65%)	9 (7%)	30 (26%)	113
Digital jigsaw (n = 7 studies)				
Academic performance	4	2	1	7
Psychosocial variables	1	0	1	2
Attitudes toward jigsaw	3	0	1	4
Total number of effects in digital jigsaw	8 (61%)	2 (15%)	3 (23%)	13

Note. This table reports the occurrence of effects, not the number of studies (one study can comprise several effects). This table excludes effects resulting from comparisons among different jigsaw versions or jigsaw phases, with the exception of the digital jigsaw section, for which some studies compared two jigsaw scripts (as seen in studies by Deiglmayr & Schalk, 2015, and Huang et al., 2011). STEM = science, technology, mathematics, and education.

saw and traditional control groups. Likewise, Karacop and Doymus (2013), who controlled for students' prior knowledge in chemistry (note that the jigsaw group showed higher prior knowledge level), found that animation group outperformed both jigsaw and traditional learning groups on the understanding of chemical concepts (open-ended questions). According to the authors, the superiority of the animation group over the jigsaw method is due mostly to animations (i.e., motion pictures) that are highly efficient for learning dynamic processes such as chemical and molecular ones.

Biology. The overall picture is mixed, as three of nine studies indicated beneficial effects of jigsaw on academic performance (Mutlu, 2018; Roseth et al., 2019; Walker & Crogan, 1998), and six studies yielded null or negative effects (Lazarowitz et al., 1994; Moreno, 2009; Slish, 2005; Stanczak et al., 2022 [Studies 2, 3B, and 3C]). Sample size varied from 52 to 313 participants. Among the three studies showing positive effects, findings from Walker and Crogan (1998) must be treated with caution because of several limitations. First, no data were available from the control groups. Second, experimental and control conditions were not randomized but rather decided by teachers who took part in the study. Third, one teacher suddenly decided to apply noninterdependent cooperative learning instead of the jigsaw procedure, but data for this brand-new group were retained by the authors as control data. Finally, only 20 participants remained in the analyses for evaluating academic achievement.

Positive effects of jigsaw documented in the two other studies are much more reliable. In their longitudinal experimental study ($n = 258$, 14 weeks), Roseth et al. (2019) found that cooperation and academic achievement (quizzes) increased over time in the jigsaw group relative to traditional learning method. Moreover, they showed through growth curve analyses that the academic achievement trajectory of jigsaw was nonlinear over time: Performance after a delay decreased more slowly compared with traditional classes. In biochemistry, jigsaw was compared with another active learning technique (Mutlu, 2018), the team game tournament, which is a blend of cooperation and competition. Although students' scores increased the same way for both groups, posttest scores in the jigsaw condition exceeded those of the team game tournament group.

Null effects were observed in comparison with traditional class (Lazarowitz et al., 1994; Slish, 2005; Stanczak et al., 2022 [studies 3B and 3C]) or individualistic learning (Stanczak et al., 2022 [Study 2]), and one study revealed negative effects of jigsaw (Moreno, 2009) among preservice teachers in botany in comparison with both individual and cooperative control groups (without resource interdependence). Moreno's (2009) results revealed an absence of difference between conditions on retention test, and lower performance on a problem-solving transfer test (in comparison with both control conditions). According to Moreno, jigsaw students might have lacked social skills to teach their peers during learning, focusing more on the transmission of information than on the elaboration and the co-construction of knowledge.

Physics. Among the six studies conducted in this field, with sample sizes varying from 49 to 286 participants, five studies showed positive effects on performance, either directly or indirectly. Two studies showed direct positive effects of jigsaw in comparison with traditional individual learning. These beneficial effects were observed among middle school (Ural et al., 2017) and undergraduates' students (Koç et al., 2010), by using either the original jigsaw or subject jigsaw, with a long implementation period (from 4 weeks to 6 months). The three other studies, conducted by the same research team (Berger & Hänze, 2009, 2015; Hänze & Berger, 2007) among high school students (17–19 years old), revealed no direct effect of original jigsaw but rather mediated or moderated effects, and highlighted the role of the expert phase within jigsaw method. Finally, null effects were found among sixth graders when jigsaw was compared with traditional learning (Stanczak et al., 2022 [Study 3A]).

The first study of Hänze and Berger (2007) compared jigsaw with traditional learning. Findings revealed no direct effect of the instruction method on performance but rather an indirect effect through feelings of competence. This mediation indicated that the jigsaw method led to higher feelings of competence, which in turn increased physics performance. In their second study, Berger and Hänze (2009) compared jigsaw to a collaborative method (i.e., cyclical rotation; see Supplemental Table S1), in which small groups have access to the whole material and work together without separate responsibilities. Again, no direct effect was found but a significant moderation by the study topic emerged: Jigsaw outperformed cyclical rotation setting for the microwave oven learning unit, whereas it was the reverse for the scanning electron microscope unit. A partial mediation indicated that the jigsaw method increased interestingness of the microwave oven learning unit, resulting in better performance. Finally, Berger and Hänze (2015) tested expert-novice differences in performance during jigsaw learning and found that expert members scored higher than novices in open-ended questions test, including schematic drawing in physics. This result deserves attention, as it supports one criticism addressed to the jigsaw method (Slavin, 1995, 1996; Slavin, Hurley, & Chamberlain, 2003), namely, that students can achieve on the part of the material in which they have been expert but not the portions of the material they have been taught by their group members.

Mathematics. The nine studies reviewed revealed mixed results. Four studies showed positive effects of jigsaw in within-subjects design (Perkins & Saris, 2001; Kritpracha et al., 2018) or in comparison with traditional class (Artut & Tarim, 2007; Tran & Lewis, 2012). Others revealed null (Moskowitz et al., 1983; Souvignier & Kronenberger, 2007; Stanczak et al., 2022 [Study 1]) or negative (Moskowitz et al., 1985; Souvignier & Kronenberger, 2007) effects. Finally, one study (Deiglmayr & Schalk, 2015) compared two jigsaw conditions by manipulating the degree (weak vs. strong) of knowledge interdependence and showed greater positive effects of weak interdependence on performance. Sample size varied from 55 to 384 participants.

Perkins and Saris (2001) found a positive effect of jigsaw after 1 year of exposure among prospective teachers and undergraduate students. They compared prejigsaw to postjigsaw exam performance and observed that jigsaw contributed to increase performance. However, null effects were observed among younger students. Moskowitz et al. (1983) found no improvement for fifth and sixth graders who learned mathematics through jigsaw for a year in comparison with traditional classes. According to the authors, this null effect might be due to the lack of a collective reward structure of jigsaw to strengthen cooperation and interdependence. Another study (Souvignier & Kronenberger, 2007) compared the effects of two jigsaw versions (original jigsaw and an enriched version) with traditional teaching–centered method on astronomy and mathematics achievement ($n = 208$, third grade students). The enriched jigsaw version comprised a questionnaire that introduced a little nudge for children: Short index cards with five questions to help children to collect concise information from their groupmates during cooperation (e.g., "What does…mean?"). Results showed no significant difference among the three groups in mathematics, but children in the traditional group scored better on astronomy tests than those in both jigsaw conditions. Souvignier and Kronenberger (2007) performed further analyses within jigsaw conditions to test whether students achieved their own expert subtopic only because of poor quality of the reciprocal teaching in the home groups (see Supplemental Figure S1 for the jigsaw steps). As expected, whereas experts achieved their own part of the materials, novices lacked understanding about many sections of the lesson, which in turn decreased the average scores. Jigsaw thus limited achievement to the subsections in which learners were experts (see also Berger & Hänze, 2015).

Deiglmayr and Schalk (2015) also hypothesized that resource interdependence settings could prevent learners to access all the information needed to engage in the co-construction of knowledge. The authors tested triads of undergraduate students, who worked on mathematical models either in a strong-knowledge interdependence condition (original jigsaw, each student in a triad is assigned one mathematical model with three different contexts) or in a weak-knowledge interdependence condition (each student in the triad is assigned three mathematical models, sharing a similar context). Prior knowledge in mathematics was assessed before cooperation. The results showed that weaker interdependence led low achievers to perform better on a transfer task than high achievers of the strong interdependence condition. This effect can be explained by the co-construction of knowledge that occurs during cooperation: When the total conceptual knowledge is given, students can easily engage in discussion about the contents to learn.

Technology. One study (van Dijk et al., 2020) tested the effects of jigsaw on the learning of technology among fifth and sixth graders. The jigsaw classroom was supported by a script (i.e., worksheet) to strengthen individual accountability and social interdependence. The students' task was to design a house on the moon that could be inhabited by a family. Performance on knowledge tests was compared with an unsupported version of the jigsaw classroom (without a script). Results showed that only low-ability students benefited from the supported intervention, with gains on performance between pretest and posttest on their assigned topic.

Language and Social Sciences Achievement

We collected 19 articles for language and social sciences. Two other studies coming from the STEM section that tested for reading performance were also included (Moskowitz et al., 1983, 1985), resulting in 21 studies. Studies tested academic performance in language arts ($n = 7$) and English as a foreign language (EFL; $n = 5$), and assessed social sciences achievement in various fields such as history ($n = 2$), geography ($n = 2$), economics ($n = 1$), psychology ($n = 2$), and educational sciences ($n = 2$). Overall, a positive pattern was observed, with 14 positive effects, no negative effects, and 5 null effects (see Table 2).

Language Arts. The findings in grammar, reading, and written expression in native language showed mixed effects of jigsaw learning. Four of seven studies showed beneficial effects on academic performance in comparison with traditional learning (Göçer, 2010; Law, 2011; Şahin, 2010, 2011). Three other studies showed null effects among young populations, namely, elementary school students (Moskowitz et al., 1983, 1985) and middle school students (Arslan, 2016). Sample size varied from 56 to 384 participants. Interesting findings regarding the effects of jigsaw on reading comprehension were reported by Law (2011). This study is one of the few large-scale assessment studies that have examined effectiveness of jigsaw among elementary school students (fifth graders, $n = 279$). The design included an original jigsaw condition, a cooperative drama class condition, and traditional whole-class condition. Children were asked to read and understand a story, then higher order reading comprehension was assessed (i.e., the ability to make inferences). Results showed that jigsaw groups outperformed those in the other two conditions on the reading comprehension task. In the delayed retest, the jigsaw groups only outperformed those from the control group. This supports the idea that in language-related subjects, jigsaw contributed to organize information in memory. Regarding written expression, Şahin (2010, 2011) also showed a better achievement in Turkish language for jigsaw group relative to a traditional learning class, in both undergraduate students and sixth graders.

On the contrary, Moskowitz et al. (1983, 1985) tested for reading abilities among 10-year-old students on the standardized subset of the Stanford Achievement Test and found no significant effects of jigsaw compared with traditional teaching. Likewise, Arslan (2016) observed no difference between jigsaw and traditional class in Turkish grammar (i.e., assessing for punctuation and spelling rules) among 13-year-old children and suggested that prior training in cooperation might be necessary for the jigsaw method to be effective among children.

EFL. Jigsaw learning seems to positively influence achievement in EFL classroom. Four of five studies showed beneficial effects on EFL performance among secondary school and undergraduate students, by testing for original jigsaw and Jigsaw II (Evcim & İpek, 2013; Ghaith & El-Malak, 2004; Gömleksiz, 2007; Rimani Nikou et al., 2013). One study showed null effects with Jigsaw II among fifth graders (Shaaban, 2006). All these studies compared jigsaw with a traditional learning class, and the implementation period varied from three class sessions to 8 weeks. Contrary to the previous sections, small sample sizes were reported here, from 28 to 66 participants ($M = 47.6$).

In line with findings obtained by Law (2011) in Chinese literature (see "Language Arts" section), Ghaith and El-Malak (2004) found a positive effect of jigsaw on higher order reading (i.e., making inferences, critical and interpretative comprehension of a text) on an adapted version of the Test of English as a Foreign Language (i.e., a standardized test measuring English language ability). However, no effect was found either on overall comprehension or on literal comprehension (i.e., understanding explicit information). Regarding vocabulary and reading comprehension, Shaaban (2006) showed that jigsaw did not improve EFL performance among middle schoolers and put forward some methodological limitations, such as a small sample size (n = 44) and the limited length of the implementation period (i.e., 8 weeks).

Social Sciences. This section reports studies assessing the effects of jigsaw on academic performance in economy, teacher education, geography, history, and psychology, with sample sizes varying from 44 to 303 participants (M = 102.3). Six of nine studies showed a positive effect of original jigsaw on achievement compared with traditional learning (Basyah et al., 2018; Huang et al., 2014; Kilic, 2008; Lucker et al., 1976; Yapici, 2016; Ziegler, 1981). Null effects were found in one study (Crone & Portillo, 2013) that compared the original jigsaw to reduced-schedule (see Supplemental Table S1) jigsaw and traditional class. Another study (Hornby, 2009) compared two versions of Jigsaw II in which the scoring system was manipulated to structure individual accountability and positive interdependence and showed that structured jigsaw outperformed the unstructured jigsaw. Finally, one study (Nolan et al., 2020) compared jigsaw experts' with jigsaw novices' performance on assigned (vs. not) topics.

In history and geography lessons, comprehension scores and semantic knowledge increased after a jigsaw exposure about different subtopics, such as Canadian demographics (Ziegler, 1981), a unit on colonial America (Lucker et al., 1976), a "science within time" unit (Yapici, 2016), or ecological environment of the water regions in Taiwan (Huang et al., 2014). A study by Nolan et al. (2020) revealed that students preferred, understood, and performed better their assigned jigsaw topic than other portions of the material. This result is consistent with other analyses made on experts' and novices' performance (see "STEM Achievement" section: Berger & Hänze, 2015; Souvignier & Kronenberger, 2007; and Slavin's criticism of jigsaw learning [Slavin, 1995, 1996; Slavin et al., 2003]). Few other studies pointed out longitudinal effects. When tested 6, 10, or 11 weeks after jigsaw (respectively, in Şahin, 2011; Ziegler, 1981; and Yapici, 2016), students were able to retrieve more information in memory than students instructed with traditional methods. In contrast, Crone and Portillo (2013) found null effects with a long implementation period (i.e., one semester). A full jigsaw schedule (regular jigsaw activities on specific conceptual units) did not improve students' grades on final exams in cognitive psychology in comparison with both traditional class and a reduced jigsaw schedule (i.e., jigsaw activities conducted less frequently and for larger conceptual units). Finally, we noticed some shortcomings in this section, such as high variability in sample size across studies (e.g., n = 44 in Hornby, 2009; n = 303 in Lucker et al., 1976) and a lack of details about the academic assessment and dependent variables (e.g., Crone & Portillo, 2013).

Vocational Achievement

We reviewed eight studies assessing the effect of jigsaw on students' performance in vocational education such as nurse training, medical care, dental education, computer sciences, engineering, cost accounting management, and video games. Original jigsaw was applied in all the studies. Positive effects ($n = 3$), null effects ($n = 3$), and negative effects ($n = 1$) were observed on achievement (see Table 2), in comparison with either traditional class or other cooperative method. One study (Lai & Wu, 2006) also compared a modified version of jigsaw in which students used a concept mapping software program within a personal digital assistant (i.e., a pocket portable computer) to a regular jigsaw classroom. One study also compared jigsaw to both individual and other cooperative control groups (Desforges et al., 1991). All these studies tested middle school, high school, or undergraduate students, but age range was not always reported. Sample size varied from 38 to 109 participants ($M = 75.2$).

Studies in this section are especially relevant, as they tested for direct effects of jigsaw in professional careers that often require social skills and teamwork. The articles we reviewed reported contrasting results (e.g., Arslan, 2016; Shaaban, 2006; Souvignier & Kronenberger, 2007). Positive effects were obtained in studies conducted among high school and undergraduate students for only one session or 3-month period of implementation. For instance, Nebel et al. (2017) showed better gaming performance and learning outcomes among teenagers ($M = 17$ years old) in the jigsaw group relative to a cooperative condition with no resource interdependence (all of the materials were available), and where cooperation was only voluntary. In contrast, no effect of jigsaw in comparison with a cooperative learning group was obtained in medicine (Desforges et al., 1991) or in design of ecofriendly houses (Zacharia et al., 2011).

Two other studies reported contrasted effects in pharmacy (Wilson et al., 2017) and dental care studies (Sagsoz et al., 2017). Wilson et al. (2017) pointed out a discrepancy between students' perceptions of the learning method and their actual performance. Whereas 95% of the participants considered jigsaw an effective learning method and reported that it improved their communication, problem-solving, and cooperative learning abilities (i.e., their "soft skills"), actual performance was not superior to that seen with traditional teaching. The authors suggested that jigsaw was perhaps not adapted to learn fundamental contents and/or would be better suited to students well trained to cooperation or with good teaching abilities. Another study (Sagsoz et al., 2017) reported no difference between traditional class and jigsaw on immediate posttest. These authors suggested that the lack of familiarity with the jigsaw procedure and the formation of initial heterogeneous groups (i.e., the home groups), might have disrupted students' habits. However, results on delayed posttest were better with jigsaw, as a lower failure rate was reported in comparison with the control condition, a finding that was not interpreted by the authors but that is similar to that obtained by Roseth et al. (2019) in biology (see "Biology" section).

Jigsaw Effects on Psychosocial Factors

The majority of the studies included for this review ($n = 43$ of 69 studies) tested for psychosocial outcomes related to intergroup relationships ($n = 11$), self-evaluations ($n = 12$), motivation ($n = 7$), and attitude toward the jigsaw classroom and subject topics ($n = 24$). The majority of studies revealed a beneficial effect, with 38 positive effects, 3 negative effects, and 12 null effects (see Table 2).

Intergroup Relationships

Eleven studies explored how jigsaw influenced social and intergroup relationships during learning at school. Sample size varied from 66 to 684 participants. Quality and frequency of students' social interactions were measured in four studies (Gömleksiz, 2007; Huang et al., 2011; Lai & Wu, 2006; Theobald et al., 2017) that reported positive effects among undergraduates. Studies by Huang et al. (2011) and Lai and Wu (2006) compared enhanced versions of jigsaw (blog-based jigsaw and jigsaw on a portable handle, respectively), and both showed positive effects in comparison with original jigsaw procedure, on social interactions between students. Only one study found unpleasant effects of jigsaw on the quality of the interactions, as mistrust issues and difficulties for communicating knowledge were reported by students (Zacharia et al., 2011).

Results were mixed regarding effects of jigsaw on interethnic relationships (Blaney et al., 1977; Santos Rego & Moledo, 2005; Ziegler, 1981) and reduction of prejudice toward minorities (Bratt, 2008; Desforges et al., 1991; Walker & Crogan, 1998). All these studies measured interethnic relationships before and after the intervention by using sociometric surveys (excluding Santos Rego & Moledo, 2005, who used an intercultural attitude scale). Five studies showed a beneficial impact of jigsaw on intergroup relationships. For instance, Ziegler (1981) found that jigsaw contributed to enhance cross-ethnic friendships among Canadian children immediately after the educational intervention and 10 weeks later. Likewise, considering another kind of stereotyped population, Desforges et al. (1991) showed that jigsaw activity decreased medical students' prejudice toward mentally ill patients. A third study (Santos Rego & Moledo, 2005) also reported positive effects of jigsaw on intercultural attitudes between Spanish pupils and other minority background pupils (Latino American, European, Romanian, Arab, and African), but the differences between conditions (between pre- and posttest and between experimental and control groups) were in fact not significant.

However, Bratt (2008) found no effect of jigsaw on attitudes, intergroup friendships, and empathy in two consecutive studies conducted in Oslo, Norway. Despite the quality of the experimental design, sufficient sample size ($n = 61$ and $n = 260$), two age levels (6th and 8th to 10th grades), and a controlled implementation of jigsaw, both studies showed no successful changes in students' intergroup attitudes or improvement in empathy levels. Walker and Crogan (1998) also tested the effects of jigsaw on reduction of ethnic prejudice by using a sociometric survey, a social distance scale, three ethnic stereotypes ratings, and reported mixed findings. For European Australian children, the jigsaw classroom helped decrease social distance and stereotypes toward Asian Australian children, but also increased negative perceptions of the Aboriginal Australian children. However, each ethnic group was not equally represented in this study. There were no Aboriginal Australian children in one of the control groups, and European Australians had to answer about stereotypes ratings regarding Aboriginal Australians, despite the fact there were none in the jigsaw group. Hence, the results of this study should be interpreted with caution (see also the "Biology" section).

It is thus difficult to conclude with certainty about prejudice reduction and positive development of intergroup relationships with such mixed results (n = 5 positive effects and n = 4 negative and null effects).

Self-Evaluations

Aronson and Bridgeman (1979) suggested that jigsaw might have a positive influence on self-evaluations and perspective taking. In this section we explore the results obtained in 12 studies testing for self-esteem (n = 4), self-efficacy or academic self-concept (n = 6), and empathy and perspective taking (n = 3). Findings are contrasted and appeared to be highly dependent on the sample size, which varied from 33 to 384 students.

Self-Esteem. The results are mixed for this self-construct, as two studies showed interaction effects and two others reported a beneficial effect of the jigsaw method, all of them in comparison with traditional learning. One of the first experimental study testing for effects of jigsaw in the classroom was conducted among fifth grade children and measured self-esteem before and after cooperative learning (Blaney et al., 1977). These authors used a composite self-esteem score based on one question about general self-esteem and three questions about academic self-esteem. The results revealed that the score significantly increased after a 6-week period of jigsaw activity. Nonetheless, the authors did not report any other significant difference between jigsaw and control groups. Later, another study conducted among high school students showed that self-esteem increased after cooperation with jigsaw in comparison with a traditional control group (Lazarowitz et al., 1994).

In contrast, two other studies (Moskowitz et al., 1983, 1985) conducted with children in fifth and sixth grades did not confirm such positive effects on self-esteem. In their first study, the authors observed an interaction effect between grade level and condition, so that fifth grade children in the jigsaw group had lower self-esteem levels than those in traditional learning group. In the second study, an interaction between gender and condition was found, showing that the jigsaw classroom benefited to girls' self-esteem but not boys' self-esteem. Such inconsistent findings from a small amount of empirical work (n = 4) do not allow a conclusion about the beneficial effect of jigsaw learning on self-esteem.

Self-Efficacy and Self-Concept. Self-efficacy can be defined as "a concern with people's beliefs in their capabilities to produce given attainments" (Bandura, 1997). Inherently connected to self-efficacy, self-concept is linked to one's beliefs about his or her competence in any domain. The subtle difference between self-efficacy and self-concept is that the former is task-dependent (for a detailed explanation, see Pajares & Miller, 1994). Both self-efficacy and self-concept can linearly predict academic performance (e.g., Pajares & Miller, 1994).

Six studies tested the effect of jigsaw on self-efficacy and/or academic self-concept, and most of them found positive effects of jigsaw ($n = 5$), all in comparison with traditional classes. Only one study revealed no difference between conditions on academic self-concept (Moskowitz et al., 1983). Studies were conducted among elementary school, middle school, high school, vocational, and undergraduate students. Crone and Portillo (2013) found that students in the jigsaw condition reported higher academic self-efficacy than those in the other conditions (i.e., reduced-schedule jigsaw and traditional learning). Likewise, Darnon et al. (2012) observed a marginal positive effect of jigsaw among vocational students ($M = 18$ years old) on a subscale measuring academic self-confidence in mathematics and French courses adapted from the Patterns of Adaptive Learning Scales (Midgley et al., 2000). Roseth et al. (2019) also used one of the Patterns of Adaptive Learning Scales measures, the "perceived competence" scale, and showed a beneficial influence of jigsaw.

As reported in the "Physics" subsection, Hänze and Berger (2007) showed that effects of jigsaw on performance were mediated by feelings of competence. Moreover, Shaaban (2006) found that reading self-concept improved after a jigsaw intervention among fifth graders and suggested that social interdependence might have led students to perceive themselves as more competent, which in turn enhanced their motivation to read. Consequently, all these studies ($n = 5$) support the hypothesis of a beneficial impact of jigsaw learning through the development of a higher feeling of self-competence or self-efficacy, which contributes itself to improve academic achievement.

Empathy and Perspective Taking. Only three studies investigated the effect of jigsaw on student's empathy. On the basis of previous findings showing that social interaction among peers can increase children perspective taking, Bridgeman (1981) hypothesized that jigsaw interventions might enhance students' role-taking ability. As expected, the results showed that 5th graders in the jigsaw condition outperformed both controls (traditional class and cooperative control without resource interdependence) on a task involving taking the role of a cartoon character. In contrast, Bratt (2008 [Study 1]) reported in a similar population (6th graders) a negative development of empathy after jigsaw activity compared with traditional classes. This result was replicated among older students, from 8th and 10th grades (Bratt, 2008 [Study 2]).

Motivation and Achievement Goals

Students' motivational levels were evaluated using motivation scales and achievement goal orientations ($n = 7$ studies). Positive effects of jigsaw were observed in two studies measuring motivation for reading (Shaaban, 2006) and science (Ural et al., 2007). Although two other studies reported that both extrinsic and intrinsic motivation (Hänze & Berger, 2007; Sanaie et al., 2019) increased after jigsaw intervention in comparison with traditional learning, studies by Berger and Hänze (2009) and Roseth et al. (2019) reported null effects of jigsaw on intrinsic motivation (i.e., measured through perceived competence, interest, and relatedness). According to Roseth et al. (2019), this null effect can be related to jigsaw's two-group composition (expert and jigsaw groups) that stimulates mixed perceptions of motivation (respectively independence and interdependence) among students.

Two other studies reported mixed effects on achievement goals (Hänze & Berger, 2007; Law, 2011). Achievement goals constitute dynamic and cognitive motivations to pursue an achievement task according to one's personal standards of competence. In the literature (e.g., Elliot & Murayama, 2008), two forms of competence are distinguished. Mastery goals are concerned with the acquisition of new knowledge and skills, while performance goals refer to comparison with peers. Law (2011) showed evidence that jigsaw students tended to report higher mastery goals than students from the traditional group. Hänze and Berger (2007) reported a main effect of mastery orientation on experience of competence (i.e., self-efficacy) but no significant interaction between mastery and instruction (jigsaw vs. traditional class) on experience of competence. Both studies raise interesting questions about the role of mastery and performance orientations on academic achievement during cooperation.

Attitudes Toward the Learning Context

Students were asked to report their attitudes regarding the characteristics of teaching in their class ($n = 24$ studies), such as attitudes toward the jigsaw activity ($n = 19$ studies), subject topics ($n = 6$ studies), and/or classroom climate ($n = 2$ studies). In most of the studies we reviewed, students reported positive views and attitudes about the jigsaw methods ($n = 15$). For instance, Perkins and Saris (2001) tested the effects of the jigsaw classroom among undergraduates in a statistics class for a year and assessed students' ratings of jigsaw. The results showed positive attitudes toward the method, as jigsaw was found to be a proper alternative to lectures for the teaching of statistics (88% of students choose the most positive scores on the rating scale).

Preferences about instructional method can also depend on student achievement level: Huang et al. (2014) showed that students who learned with jigsaw were more satisfied than students in traditional groups, and that low achievers liked jigsaw activity better than medium and high achievers. On the contrary, high achievers preferred individual learning to learn at their own pace. Regarding attitude toward subject topic, three studies reported positive effects (Gömleksiz, 2007; Sahin, 2010; Shaaban, 2006), whereas three others (Arslan, 2016; Lazarowitz, et al. 1994; Sengul & Katranci, 2014) showed null effects. For instance, Şengül and Katranci (2014), who conducted a within-participants study, found no effect on attitudes toward mathematics after a jigsaw exposure on geometry learning among a younger population (i.e., seventh grade). Although a general positive view of the jigsaw method is observed, participants also declared mistrusts issues during jigsaw activities (Zacharia et al., 2011), lack of comprehension of the topics (Artut & Tarim, 2007), and found learning with jigsaw effortful (Suárez-Cunqueiro et al., 2017). Finally, Moskowitz et al. (1983) showed that classroom climate was reported as less competitive following jigsaw intervention, while Lazarowitz et al. (1994) reported no difference between conditions.

TABLE 3.

Summary of research trends, research gaps, and research integrity in 40 years of research on the jigsaw classroom.

Category	Description
Research trends	Research focused somewhat more on jigsaw effects on academic outcomes than on psychosocial variables.
	Among academic outcomes, effects of jigsaw were predominantly investigated in STEM fields relative to language, social sciences, and vocational fields.
	Among psychosocial variables, effects of jigsaw were predominantly investigated on attitudes toward the learning method and context, followed by self-evaluations and motivation, with only a minority of studies addressing intergroup relationship and racial conflict.
	The jigsaw classroom was more frequently compared with traditional learning methods than with other cooperative learning methods.
	The effects of the jigsaw classroom were tested mainly among undergraduates, with only a minority of studies conducted on children.
Research gaps	Little research has been conducted on the underlying mechanisms of the effects of jigsaw (mediating and moderating variables) to understand why, under what circumstances, and to whom this method can be beneficial. Both cognitive, psychosocial, and contextual variables could play a significant role and help understand negative and null findings.
	The few studies comparing the jigsaw classroom with other cooperative learning methods do not allow to understand what characteristics of each method drive the findings.
	Further research is needed to clearly understand the contribution of the expert phase of the jigsaw method to the whole academic performance.
	No study to date has examined the effect of jigsaw on cooperative skills, by measuring the development of students' social skills (e.g., cooperating, negotiating, sharing information).
Research integrity	Important information necessary for reproducibility is lacking in many studies: (a) contents of the lesson or the procedure (timing phases), (b) instructions for the control groups (i.e., working phases, material, role of the teacher), (c) characteristics of the sample (i.e., grade, age, level), and (d) size and composition of the working group (i.e., homogenous or heterogeneous groups).
	Most of the studies reviewed did not use parallel forms (different tests), so that the interpretation of posttest scores can be biased by a "testing effect" phenomenon.
	A limited number of details were provided regarding the required statistical parameters to compute mean effect sizes (i.e., sample size, standard errors, test mean scores on pre- and posttest, pre-post correlations) so that meta-analyses cannot be performed.

Note. STEM = science, technology, mathematics, and engineering.

Discussion

The goal of this study was to provide a systematic review of the effects of the jigsaw cooperative learning technique (Aronson et al., 1978) on the ground of 40 years of research conducted either in the field or in laboratory. This review first revealed a rather small number of empirical studies (according to our inclusion criteria) on the jigsaw classroom (n = 64 articles, n = 69 studies), supporting previous criticism about the gap between the popularity of this method and the available scientific evidence (e.g., Roseth et al., 2019). Such a small number notwithstanding, the review also contributed to highlight research trends, research gaps, and issues of research integrity in this literature (see Table 3 for a complete presentation). Although the jigsaw classroom was originally designed to improve academic performance of minority children by reducing intergroup conflict and increasing participation, empathic role taking, and self-esteem (e.g., Aronson & Bridgeman, 1979), most studies focused on undergraduate academic performances, predominantly in STEM fields, with only little interest in intergroup relations and other underlying mechanisms of the jigsaw method. In particular, as far as research integrity is concerned, it appeared that the results presented in many studies we reviewed had to be interpreted cautiously because of several methodological limitations; they had already been pointed out in previous research (see Bratt, 2008; Moskovitz et al., 1983; Roseth et al., 2019), and here they emerge in a systematic manner. Below, we summarize for the first time since its creation the effects obtained with jigsaw on academic achievement (Research Question 1) and psychosocial factors (Research Question 2). Next, we discuss the challenges of jigsaw activities and the limitations encountered in this literature. Finally, we conclude with some practical implications.

Beneficial Effects With the Jigsaw Classroom

Results revealed at first sight beneficial effects of jigsaw (see Table 2) on academic performances (60% of the studies) and a mixed pattern for psychosocial variables (53%). However, beyond a quite positive global picture, findings are in fact rather mixed. Indeed, if positive effects of the jigsaw classroom on academic achievement were predominant in language arts and social sciences (73%), they were less or slightly better than chance in vocational (42%) and STEM fields (55%). These results support the idea that the jigsaw method could be more adapted for teaching subjects with narrative or textual contents (Aronson & Patnoe, 2011; Mattingly & Van Sickle, 1991). One can assume the semantic knowledge related to literary subjects to be more appropriate to learning with jigsaw methods than reasoning or cognitive demanding tasks (e.g., resolving a first-order equation in a mathematics worksheet). This hypothesis might explain the modest advantage of jigsaw in literary subjects but should be documented by more empirical studies assessing both problem-solving and semantic knowledge–related tasks.

Interestingly, the few studies reviewed that tested whether jigsaw improved academic achievement over time showed benefits on retention of knowledge on performed delayed tests (eight of nine studies). Jigsaw appears to slow down classic decline effects usually observed on academic outcomes such as motivation (e.g., Linnenbrink-Garcia et al., 2018; Otis, Grouzet, & Pelletier, 2005) and academic performance (e.g., Wijsman et al., 2016). Although the jigsaw classroom does not always demonstrate immediate effects on academic achievement, it is likely that gains can be observed further away from the learning process. Although these costs may be detrimental pose challenges for some students, it is also likely that working with jigsaw could be seen viewed as a “desirable difficulty” (Bjork & Bjork, 2020): in the sense that the high levels of organization, coordination, and cognitive costs demands could trigger stimulate encoding and retrieval processes that support enhance learning, comprehension and memory. In this regard, previous research showed that group work can enhance individual memory under specific circumstances (Congleton & Rajaram, 2011; Rajaram & Pereira-Pasarin, 2007), resulting in gains on recall and recognition performance. Researchers and teachers should consider this delayed effect when using the jigsaw classroom. However, we should note that, when observed, the positive effects of jigsaw on academic outcomes were obtained in comparison with individual learning. Among the small number of studies that have compared jigsaw with other cooperative learning ($n = 11$), the jigsaw method, whatever its version, was not superior. This raises the question of the added value of jigsaw relative to other cooperative learning method.

Regarding psychosocial variables, an important part of the observed positive effects of jigsaw comes from measures of students’ attitudes toward the learning context. The pattern from other and more important variables for the understanding of jigsaw efficiency is less clear. Although jigsaw displayed, on average, beneficial effects on self-efficacy (or feeling of competence) and motivation, it was associated with mixed effects on self-esteem and prejudice reduction, which does not support Aronson and colleagues’ main assumptions (Aronson et al., 1978; Aronson & Patnoe, 2011). It is possible, however, that the instruments administered in the studies to assess self-esteem were not optimal as they measured global self-worth. Multidimensional instruments, measuring for domain-specific self-concepts such as academic self-esteem, would be more appropriate for investigating whether jigsaw methods affect self-esteem perceptions in educational contexts. More important, no study to date has contributed to supporting evidence for an effect of jigsaw, as initially assumed by Aronson and Patnoe (2011), on cooperative skills, by measuring the development of students’ social skills (e.g., cooperating, negotiating, sharing information). Finally, students from elementary to college grades reported positive perceptions of jigsaw as a method, while attitudes toward subject (e.g., biology, reading, mathematics) after jigsaw exposure were more mixed.

The Challenges of Jigsaw Activities

The overall picture in terms of outcomes is, as noted, rather mixed. We argue that such diversity of results is due—besides the specific methodological shortcomings of some studies—to the fact that the jigsaw method is challenging for students. The challenge is both cultural and cognitive. As far as the cultural challenge is concerned, it should be recognized that cooperative learning methods in general, and the jigsaw classroom in particular, are not mainstream approaches in regular teaching, which renders them rather unusual and difficult to understand to most students (Buchs, 2020). This state of affairs comes with two consequences. On the one hand, students lack a culture of cooperation, and the interest and goals of positive interdependence need to be explained and trained (see also Sagsoz et al., 2017; Wilson et al., 2017). For example, Buchs et al. (2016) deployed a classroom intervention with university students, in which they introduced three conditions: individual, cooperative learning, and cooperative learning with instructions explaining why and how to cooperate in the task at hand. The results on learning outcomes revealed a linear trend, showing that the positive effects of cooperative learning can be improved if its reasons and underpinnings are explained. On the other hand, students lack the skills that render a cooperative structure effective. Indeed, several researchers suggested that students lacked the social skills (i.e., coordination) that are necessary to cooperate with their peers (Arslan, 2016; Moreno, 2009; Shaaban, 2006; Souvignier & Kronenberger, 2007). According to Johnson et al. (2009), interpersonal and small-group skills are preconditions for effective cooperation, but these skills need to be taught and developed (Buchs & Butera, 2015).

One promising avenue of research lies in the preparation of students for collaboration prior to learning, both in terms of skill development (Buchs & Butera, 2015) and representation of the value of cooperation (Buchs et al., 2016). Preparation tasks may consist in short periods of group activities (dyads, triads) during which students are encouraged to organize information transmission, peer interactions and note taking, in a way that is analogous to further cooperative work (see Zambrano et al., 2023 for a recent review) to provide task-specific experience to students. For instance, Zambrano et al. (2023) showed that providing students with rules to support collaboration before group learning was favorable for learning and performance and reduced the perception of the cognitive load. Furthermore, other cooperative methods, such as Think-Pair-Share (Lyman, 1992) and Learning Together (Johnson & Johnson, 1999), have been demonstrated to enhance social skills (see Buchs & Butera, 2015). We suggest that combining these methods (preparation to collaboration and use of other collaborative techniques) before the jigsaw classroom would be a way of addressing this cultural challenge.

Certainly, the absence of a cooperative culture cannot solely be attributable to the individual capacities of students, whether they be cognitive or social. Instead, it extends to a general orientation toward competition of the educational system (Butera, Świątkowski, & Dompnier, 2021) and, as a consequence, the pedagogical practices used by educators (Butera, Batruch, et al., 2021). From our perspective, proactive measures initiated at an earlier stage, starting with teacher training, are also imperative to manifest the advantages of collaborative work. It is undeniable that, in the current educational landscape, particularly in the Western context, the teaching profession serves not only an educational purpose but also plays a role in student selection. Furthermore, the process of teacher training perpetuates and upholds competitive values (Butera, Batruch, et al., 2021). In our opinion, exposing teachers to cooperative values, cooperative learning methods, and mastery goals are the next step for the successful implementation of (jigsaw) cooperative intervention.

As far as the cognitive challenge is concerned, the jigsaw classroom is a complex device that requires students to understand both the method and the partners. On the one hand, despite jigsaw's specific characteristics (e.g., resource interdependence, task specialization) likely to promote a better use of individual cognitive resources, little research has investigated the underlying cognitive processes of this learning method. Only two studies (Moreno, 2009; Nebel et al., 2017) have examined the link between the jigsaw classroom and the learner's subjective mental load. First, Moreno (2009) predicted and found that students in jigsaw groups reported higher levels of perceived cognitive load than students learning individually, because of the cooperative activities (i.e., sharing, elaborating ideas) that can impose additional (extraneous) load on learners. Second, following the assumptions of a "collective working memory effect" (Kirschner, Paas, & Kirschner, 2009, 2011), Nebel et al. (2017) assumed that the individual cognitive load would decrease among jigsaw members, because of division of the task costs between group members. However, results did not support this hypothesis, with jigsaw participants rather showing higher amount of invested mental effort. Further studies should continue to investigate the potential cognitive load effects imposed on learners, not only by examining the perceived load, but also any real system load, for example, by measuring students' individual and collective working memory capacities (see Vives et al., 2024). Although these costs may be detrimental for some students, it is also likely that working with jigsaw could be seen as a "desirable difficulty" (Bjork & Bjork, 2020), in the sense that the high levels of organization, coordination, and cognitive costs could trigger encoding and retrieval processes that support learning, comprehension, and memory.

On the other hand, the positive interdependence on which jigsaw groups are built makes all group members dependent on the quality of the work conducted by the partners and the ability to understand them. In an experiment with university students, Buchs, Butera, and Mugny (2004) manipulated positive resource interdependence (vs. independence) and measured delayed learning outcomes. Their results showed that in the positive resource interdependence condition, but not in the resource independence condition, learning increased as perceived partner's competence increased (see also Buchs et al., 2021). In other words, under positive resource interdependence understanding one's partner is a crucial determinant of learning.

In summary, the jigsaw method confronts students with both a cultural and a cognitive challenge that require students to learn how to function in such a pedagogical environment, in addition to learning their course materials. Such learning may require time. We have noted that eight of nine jigsaw studies with delayed tests displayed benefits on retention of knowledge, but more studies with interventions and longitudinal designs are needed (Harackiewicz & Priniski, 2018).

Among the studies collected, we observed 5 positive effects when implementing the jigsaw classroom for one or two sessions (n = 15 studies), 6 positive effects for a duration of 2 to 3 weeks (n = 9 studies), and 18 positive effects for a duration spanning from 4 to 5 weeks up to 1 year (n = 45 studies). We will maintain this pattern of results purely descriptively, as drawing conclusions regarding an optimal intervention length would be misleading because of the unequal distribution of papers across these categories. Currently, a compelling need persists for a critical evaluation of the jigsaw classroom using randomized and controlled experimental designs. We recommend that future studies address these methodological inquiries by directly testing the implementation length (e.g., hours, weeks, months, year), frequency (e.g., twice a week), and the culture of cooperation (e.g., one class, one course, the whole scholarship course) required for effective learning with the jigsaw classroom. Interventions would be instrumental to introducing the method in such a way as to allow students to familiarize themselves with a new way of working, but most of all with a new set of values and skills (Buchs et al., 2016). Longitudinal studies—with several points of measure making it possible to compute growth curves—would be essential to document the possible evolution over time of learning outcomes and psychosocial factors.

The present article is the first to review the effects obtained with the jigsaw method on academic achievement and psychosocial factors in a conjoint manner, and the review points to the potential interest in promoting research that documents the interplay between these two classes of factors. Future studies should therefore extend process-oriented research in cooperative learning (Janssen et al., 2010) by arising interest in mechanisms occurring during jigsaw learning instead of conducting product-centered research (that answers exclusively to the question of whether jigsaw is better than other learning instructional methods). Following Janssen et al.'s (2010) proposition to dismantle the cognitive "black box" of cooperative learning, one could expect more direct evaluations of well-known cognitive mechanisms involved in learning. For instance, future work might consider addressing student's working memory capacities during jigsaw intervention, as this executive function plays a critical role for learning and handling complex cognitive tasks (Cowan, 2014; Vives et al., 2024), by measuring potential cognitive load during learning (e.g., Kirschner et al., 2011).

As suggested by Roseth et al. (2019), another fruitful way to disentangle jigsaw effects could be breaking down the different stages of jigsaw to clarify the processes occurring when students are in the experts or jigsaw group. As our results suggest, the expert phase appears to be primarily responsible for the beneficial effects of jigsaw on academic performance. Future research could explore the use of repeated expert phases for learning an entire piece of educational content over an extended period, possibly spanning several weeks. This could allow students to master each section of the material, addressing concerns raised by critics of the method regarding the lack of learning experience for novices (Slavin, 1995; Slavin et al., 2003). Another advantage of breaking down the different stages would be, as also noted by Roseth et al. (2019), to focus to the various forms of sociocognitive conflicts that may arise during interactions at different stages of the jigsaw procedure. The theory of sociocognitive conflict (Doise & Mugny, 1984) posits that disagreement between opposing points of view may be regulated in two different ways. Relational regulation occurs when partners stick to their point of view and try to demonstrate that they are right and the others are wrong. Epistemic regulation occurs when partners consider the others' points of view and try to integrate them with their own (for more recent and differentiated models, see Butera, Sommet, & Darnon, 2019; Lee & Roseth, 2022). As Roseth et al. found that "increases over time in jigsaw students' cooperation and epistemic regulation were associated with larger increases in academic achievement (quiz scores) compared with business-as-usual" (p. 161), training teachers and students to use epistemic conflict regulation during interactions would be a theory-based recommendation that might boost the effect of the jigsaw procedure.

A culture of cooperation can also foster an error-friendly environment, namely, a positive error climate (following the conceptualization of perceived error climate in the classroom by Steuer, Rosentritt-Brunn, & Dresel, 2013). Importantly, recent research has shown that a positive error climate in the classroom can promote learning (see Soncini et al., 2022). In line with our previous suggestion of breaking down the different phases of the jigsaw classroom, we offer a practical suggestion to educators. Evaluating students' progress should extend beyond relying exclusively on overall scores and should instead involve a thorough analysis of their errors. To quote Bastien and Bastien-Toniazzo (2016), students do not always do what we think they are doing. Their errors provide a valuable array of indicators, shedding light on cognitive aspects that may require attention, such as encoding or knowledge acquisition. During the return phase within the jigsaw groups, it is acknowledged that errors may arise as experts convey information to their novice peers. Teachers can identify these errors to enhance their pedagogical materials, possibly by incorporating worked examples, strengthening conceptual connections, minimizing the level of interaction between elements, and so forth. Such an approach can substantially support students in their learning process. To address both cognitive and cultural challenges, we finally urge future studies to focus on the exploration of interindividual differences to get a better picture of the true efficacy of the jigsaw classroom, by measuring individual characteristics well-established in the educational literature to play an important role on learning (e.g., such as working memory capacities, self-esteem, and self-efficacy) and structural features of learning (e.g., previous knowledge, group composition, quality of the transmission).

Limitations

Several reservations must be expressed regarding clarity and trustworthiness of the results we collected. First, we noted in many articles the glaring omission of information about populations, measures, and procedures. We were surprised by the lack of details about (a) the contents of the lesson or the procedure (timing phases), (b) the instructions for the control groups (i.e., working phases, material, role of the teacher), (c) the sample (i.e., grade, age, level), and (d) size and composition of the group (i.e., homogenous or heterogeneous groups). Another limitation was the use of identical assessment instruments to measure pre- and posttest students' achievement. Most of the studies we reviewed did not used parallel forms (different tests), so that the interpretation of posttest scores can be biased by a "testing effect" phenomenon (for an example applied to certification test, see Zhou & Cao, 2020). Multiple exposure to the same material can enhance recall and recognition during achievement that in turn can artificially enhance learning scores. Therefore, the usual recommendation is to use parallel forms to avoid such psychometric bias.

Furthermore, an important issue was the lack of information usually collected to perform meta-analyses. There was a limited number of details regarding the required statistical parameters to compute the mean effect sizes (i.e., sample size, standard errors, test mean scores on pre- and posttest, pre-post correlations). Effect size is straightforward to compute and allows researchers to get concise and pragmatic information about the magnitude of the difference between experimental and control conditions on a response variable (e.g., academic achievement). Moreover, there was a risk for statistical heterogeneity (inconsistency among studies) across the studies we collected. According to Higgins et al. (2021), in the presence of considerable variation in the direction of the results, it might be misleading to compute a global effect size for one intervention effect. Therefore, performing a meta-analysis on jigsaw articles could reflect a biased effect size (not the true effect), as effect size only reflects findings from the publications included in one's meta-analysis. Additionally, for a number of moderators (e.g., control condition, intervention design, population, jigsaw version) the variability was small, suggesting weak clinical heterogeneity (see Higgins et al., 2021). For instance, the tested population was mainly undergraduate students, and the original jigsaw version was the most used across studies. Altogether these issues can account for the fact that no past or recent meta-analysis about jigsaw method has been conducted yet.

We should also mention the limited number of studies performing appropriate statistical analyses to examine data in this literature. Most of the authors performed ordinary least squares models such as one-way analyses of variance or independent *t* tests, with instruction learning as independent factor and academic achievement (or psychosocial factors) as response variable. Surprisingly, gender, age, academic level, and socioeconomic status were barely tested as potential moderators of academic performance. Yet linear models testing for interaction between instruction learning condition and these factors would bring light on conditions of success and failure of jigsaw method, explaining for whom and in which circumstances jigsaw is efficient. Moreover, mediation and path analyses that allow to test for inferences as regards mechanisms responsible for the observed effects were scarcely used by researchers testing for jigsaw interventions. To date, group processes and individual mechanisms (be they cognitive or social) associated with jigsaw learning are still unknown and deserve further investigation.

A final caveat emerging from the present literature review is that basic assumptions of the ordinary least squares models, such as homoscedasticity, independence of cases, and normality of the distribution are often violated with data collected in classrooms (Bliese & Hanges, 2004; Bressoux, 2007). Because data are nested, every observation (i.e., student) can be influenced the same way by environmental macro-units (teacher, classroom, school). One recommendation is to apply multilevel models that are appropriate to analyze the effects from a global environment and the links between interindividual observations and factors of interest (for an application to educational data, see Bressoux, 2020). Faced with such a limitation, the legitimate question that arises is to know which are the findings in the jigsaw literature that scholars but also teachers and educational practitioners can trust. There is clearly a need to strengthen research integrity on this topic.

Conclusion: Practical Implications in the Context of Digital Education

Limitations aside, the jigsaw method revealed that the introduction of social interdependence in the classroom can have positive effects on both academic and psychosocial outcomes. Now, the question is whether such benefits are linked to the division of the pedagogical material, the resource interdependence, the individual accountability, the expert phase, or all these jigsaw components at once. More generally, the in-depth study of collaborative methods, their effects, and exact conditions of their effectiveness still represent a challenge.

This challenge is perhaps even more important today because of a digital transition that affects all spheres of our personal and professional life. Digital technologies offer unprecedented opportunities for collaborative learning and real-time support for class management (e.g., forming student groups, monitoring the engagement of learning, deciding when and how to intervene in their learning activities; see Chen et al., 2018; Clark, Tanner-Smith, & Killingsworth, 2016; Dillenbourg, 2021; Jeong, Hmelo-Silver, & Jo, 2019). However, as sophisticated as they can be, the digital tools in support of collaborative learning methods can only be effective if the methods themselves are well understood and guided by a detailed knowledge of the cognitive and sociocognitive processes they activate (see Noetel et al., 2022). Digital tools in the service of collaborative learning do not guarantee anything in themselves and therefore do not dispense with solidly constituted scientific knowledge on collaborative learning per se. On the contrary, we have never needed this knowledge so much, because of the rise of the digital transition in education. The present review invites us to continue the effort initiated for decades to precisely identify the optimal conditions for collaborative learning and avoid technologizing methods without any scientific basis (Leroux, Monteil, & Huguet, 2017).

Our review also indicates that several studies successfully implemented jigsaw cooperative scripts on different media, such as computers (Deiglmayr & Schalk, 2015; Huang et al., 2011; Moreno, 2009; Nebel et al., 2017; Zacharia et al., 2011), mobile phones (Parsazadeh et al., 2018), and tablets (Huang et al., 2014) or in combination with engineering math software (e.g., Mathcad; Cerón-García et al., 2022). The consistent finding across these studies was a greater level of social interactions among students, which contributed to positive views about the instructional procedure and a crucial role in learning gains for different age groups (middle school, high school, and undergraduate students). These findings are encouraging but say nothing about the reasons why the jigsaw method does not systematically produce the expected results, particularly in terms of academic performance—another reason not to abandon research on the method itself before trying to digitize it.

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