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Seven Ways of Constructing Knowledge Through Cooperative Learning

This article presents seven ways to construct knowledge through cooperative learning. The first part of the article provides a comprehensive examination of how deeply constructivist and cooperative learning discourses are interconnected and have interfaced with each other over the last five decades. The article highlights how the two concepts have influenced each other and how their combination can lead to a more effective learning experience. The second part of the article is devoted to explaining the seven ways of constructing knowledge in cooperative learning settings. Each of the seven ways - interactive, positively interdependent, synergic, synoptic, multicontextual, interferential, and action-based - is discussed in detail, with specific examples provided to illustrate how each approach works in practice. The overall aim of the article is to assist educators and researchers in understanding the various cooperative learning approaches and their potential benefits in constructing knowledge. The article emphasizes the importance of adopting simple cooperative approaches for efficient knowledge construction, and the importance of educators and researchers adapting these approaches to meet the needs of their students.

Keywords: Cooperative Learning, constructivism, knowledge construction, interactive learning

The Intertwining of Constructivism and the Cooperative Paradigm

In the first part of the study, we will briefly review how cooperative learning has intertwined with constructivist aspirations that have emerged in the educational discourse. Both discourses represent central approaches to cognitive development and learning constructed in social interactions. We will cover the paradigmatically new approach that cooperative learning brings to this field. We will also briefly mention what additional dimensions of social learning conditions have been revealed in the discourse of cooperative learning.

Mutually reinforcing insights in the two discourses:
the social determinism of knowledge construction

Interpreting learning and teaching practices from the constructivist perspective, it does not matter whether one learns through lectures or in a collaborative learning environment. In both situations, their mobilized and emerging knowledge constructs are and remain indi-

vidually different. At the same time, thanks to the constructivist discourse, it has also become understandable that these unique knowledge constructs are set in motion through social interactions. The constantly changing, interacting dynamics of learning and cognitive development are formed through the social environment and interactions with peers. Knowledge and cognitive development are fundamentally generated through social influence (Wertsch, 1979, 1980, 1992; John-Steiner & Mahn, 1996; Palincsar, 1986, 1998).

In the 1980s, it became clear that the educational approach and practice of cooperative learning were closely intertwined with socio-constructivism (Graves, 1983; Palincsar & Brown, 1984; Brown & Palincsar, 1989; Damon, 1984; Davidson, 1985; Slavin, 1987; Stevens et al., 1987; Dansereau, 1988). The crucial question in both discourses was whether individual constructs of knowledge are socially determined and how social interactions can be transformed, for example, in schools, so that each student can learn more successfully. If we examine the nature of traditional pedagogical practice based on lectures and individual learning, we can see that only a few students can interact while learning. If all students interact, it's only for a short time and primarily with the teacher. This kind of social interaction benefits those who have a good understanding of the way the teacher performs and instructs individual learning (Aronson, 2021; Kagan, 2021; Jacobs et al., 2022).

The discourse of cooperative learning also examines how the social environment, the organizational frameworks that shape social interactions, should be transformed. How can we create a learning space in which the consolidation of individual knowledge becomes increasingly optimal for all participants? It is no coincidence that in Davidson's edited book featuring pioneers of the cooperative discourse, (including Eliot Aronson, David Johnson & Roger Johnson, Robert Slavin, Yael Sharan & Shlomo Sharan, Spencer Kagan, et al) presenting the last fifty years of the cooperative learning discourse, Davidson identifies constructivism as one of the defining theoretical foundations of cooperative learning (Davidson, 2021b, p. 245). Similarly, twenty years earlier, Slavin, with his fellow authors, identified constructivist educational science as a defining element of the cooperative learning discourse (2003).

Similar foci in both discourses: learning as social interaction

Educational studies based on constructivism draw attention to interaction, specifically the interaction between students and the teacher communicating with them through dialogues aimed at realizing learning at the academic level (Wertsch, 1992; John-Steiner & Mahn, 1996; Palincsar, 1986; Mercer, 2008; Mercer et al., 1999; Alexander, 2001, 2006, 2018). Several approaches focused on social interaction have been developed to promote cognitive development and social knowledge construction, including Reciprocal Teaching (Brown & Palincsar, 1989; Palincsar, 1986; Palincsar & Brown, 1984), Collaborative Reasoning (Anderson et al., 1998, 2019), Instructional Conversation (Goldenberg, 1992), Questioning the Author (Beck et al., 1996), Exploratory Talk (Mercer et al., 1999), Dialogic Classroom (Alexander, 2001, 2008, 2018), and Accountable Talk (Asterhan et al., 2015; Resnick, 2018). The listed models and the associated pedagogical practices and research results demonstrate the constructivist approach's focus on social interactions. These models also exemplify how researchers use scientific narratives and developed models in professional dialogues, while approaching reality through constructs of individual knowledge. Among other constructivist approaches, the above listed models have slowly accumulated scientific justification over the past five decades. In addition, knowledge construction based on conscious constructive interactions understood by both teacher and student have also been developed and researched. It is crucial to follow Alexander's suggestion (2018) that teachers

should have a repertoire of models, so they can choose the most suitable model, process, and practice for a particular group of students and learning situation.

In the same way, the cooperative learning discourse emphasizes the importance of social interactions for learning and cognitive development. The cooperative paradigm assumes that students working together and helping each other in a structured way can result in better learning outcomes (Johnson & Johnson, 1999; Kagan, 1994). The focus is on the social structures and processes that enable effective and productive collaboration, such as positive interdependence, individual accountability, face-to-face interaction, interpersonal and small group skills, and group processing (Johnson & Johnson, 1989). By creating a supportive and collaborative learning environment, together students can construct knowledge and meaning and help each other learn (Davidson, 1996; Slavin, 1995). The goal is to create a learning community in which everyone can contribute and benefit from the social interactions and the collective knowledge that is constructed (Dillenbourg, 1999). The cooperative learning approach is effective in a variety of contexts, including classrooms, universities, and workplace training (Johnson & Johnson, 2009; Slavin, 2014). Like the constructivist approach, cooperative learning recognizes the social nature of learning and emphasizes the importance of social interaction in the process of knowledge construction.

In addition to promoting effective cognitive development and learning performance with equal opportunities, cooperative learning discourse also focuses on developing students' intrapersonal and interpersonal competencies and has proven its effectiveness through hundreds of research studies in recent decades. These include models such as Jigsaw Classroom (Aronson, 1972, 2021), Learning Together (Johnson et al., 1984; Johnson & Johnson, 2021), Group Investigation (Sharan & Sharan, 2021), Structural Approach (Kagan, 1990, 2021), Small Group Discovery (Davidson, 1985, 2021), and Complex Instruction (Cohen, 1986; Cohen & Lotan, 2014; Lotan & Holthuis, 2021). Cooperative learning discourse has also produced several working models that emphasize student interaction and dialogue, with a particular focus on the constructivist approach to learning. Examples of such models include Creative Controversy (Johnson & Johnson, 1992), ThinkTrix (Lyman, 1992), and Brain-Friendly Learning (Kagan, 2014), as well as Group Investigation and Small Group Discovery models, which emphasize joint knowledge construction among students in small groups. Additionally, cooperative learning has been widely adapted to incorporate Bloom's taxonomy (Bloom, 1956; Anderson et al., 2001) and the SOLO taxonomy (Biggs-Collis, 1982; Hooks & Mills, 2011, 2012) into the learning processes of different subjects (see, for example, Gillis, 2021; or Kagan & Kagan, 1998, 2009; Kagan, 2014).

Arató (2013, 2014) argues that different models of cooperative discourse are more com-prehensible within a paradigmatic approach (Kuhn, 1970). In such an approach, concrete and simple rules, "symbolic generalizations" (Kuhn, 1970), of a recognizable paradigm are drawn, along which it is possible to distinguish cooperative learning from other small group activities (for example, with the help of cooperative principles – Kagan, 1990, 2021; Arató, 2014; Jacobs et al., 2022). A paradigmatic exemplar (Kuhn, 1970) was also presented in the discourse. This is a practical example that all discourse authors recognize as a good example, and even a model, for implementing cooperative learning. It is the cooperative jigsaw structure, one of the first models developed by Aronson et al. (1978) under the name Jigsaw Classroom (Aronson, 1972, 2021).

The fundamental question of cooperative learning, like the constructivist approach in the seventies, was how to ensure successful education for all in democratic societies and create a pedagogical environment where everyone can access the goods available through knowledge. In the United States of America, for example, not only white middle-class stu-

dents should succeed in the education system, but also learners from diverse backgrounds, such as Blacks, Latinos, and Indigenous people. The desegregation measures launched in the wake of the discoveries of social psychology and human rights movements initially generated interethnic conflicts rather than increased the chances of more successful learning. Aronson and his fellow researchers – one of the discourse-founding cooperative learning workshops – wanted to achieve positive changes in the relationship between learners by changing behavioral frameworks and social behaviors of knowledge construction (ARONSON, 1972, 2007, 2021).

Instead of knowledge construction activities traditionally based on lectures and individual work, new learning structures were conceived where students are forced to speak constructively to each other. Representatives of cooperative learning transformed the behavioral framework of the lessons to create new social forms of knowledge construction. They formed behavioral structures that organizationally guaranteed each student's participation in social interactions for learning. To do this, they followed paradigmatically new principles such as parallel interaction or positive interdependence. That is, instead of the solo interaction of the teacher and one student, they allowed the students to talk to each other about what they had learned – for example, arranged in pairs or groups of three or four learners. With this step, they multiplied the number of interactions for learning during a given lesson. They created an interaction-based learning environment for knowledge construction between socially and culturally different peer groups. In the meantime, they also realized that learning tasks should be designed for essential learning interactions so that participants cannot solve them without each other. So, for example, in the Jigsaw Classroom, a particular learning behavior structure associated with Aronson and his colleagues, it is essential that everyone has an individual task, but they finish their learning assignment only when everyone learns from each other what they have learned individually.

Arató (2013, 2014) proves in several of his writings that this approach based on cooperative principles is not simply different from previous pedagogical approaches but also bears the hallmarks of an independent paradigm. On the one hand, parallel interaction is realized when a teacher breaks down the class into pairs or micro-groups. On the other hand, as a cooperative principle, it can also be followed consciously. The aim is for each learner to participate in learning interaction at the same rate as their peers in as much time and quality as possible. In the literature, the principle of parallel interaction has become generally accepted. It is known in several formulations: face-to-face, knee-to-knee, promotive interaction (JOHNSON et al., 1984, JOHNSON & JOHNSON, 1999, 2021), simultaneous interaction (KAGAN, 1990, 1992, 2021), inclusive parallel interaction (ARATÓ, 2013, 2014, 2018, 2023), maximum peer interaction (JACOBS et al., 2022).

A similarly paradigmatic principle is the principle of positive interdependence, the essence of which is to design learning tasks in such a way that the learners are dependent on each other for their execution while everyone follows individual tasks. This principle is also known as positive interdependence (JOHNSON – JOHNSON, 1984, 1999, 2021, KAGAN, 1990, 2021, COHEN, 1984, 1986, COHAN & LOTAN, 2014, LOTAN & HOLTHUIS, 2021) or mutual interdependence (ARONSON, 1972, 2006, ARONSON et al., 1978), or constructive and encouraging interdependence (ARATÓ, 2013, 2014, 2017).

Over the past fifty years, it has been shown that, in response to the old interethnic challenges, the paradigmatically new glasses (KUHN, 1970) of cooperative learning allow the creation of a social knowledge-constructing environment in which interethnic relations are positively formed. Already during the first research results, and then in the decades since, it has been continuously proven (ARONSON, 1972, 2006, 2021) that the participants show a higher level of intra- and interpersonal competency, while each student's performance is also higher than that of their peers studying in a classical behavioral framework.

David and Roger Johnson and their colleagues also conducted meta-analyses over several decades (Johnson & Johnson, 1989, 2009; Johnson et al., 2000), comparing the effectiveness of competitive, individual, and cooperative learning structures. Meanwhile, it became clear that the learning performance of each learner also increases in a cooperatively structured interactive learning environment, examining the effectiveness of learning in any discipline. For example, over the past fifty years, Davidson (Davidson, 1985; Davidson & Kroll, 1991; Davidson & Worsham, 1992; Davidson, 2021) and his colleagues in the field of mathematics and Slavin and his colleagues (Slavin, 1987; Stevens et al., 1987, Slavin & Madden, 2021) have demonstrated the higher effectiveness of cooperative structures specifically in the field of literacy.

Like the cooperative paradigm, there are decades of evidence in the constructivist tradition of peer interaction and, to that end, of the teacher's task differently, for example, in the field of literacy (Anderson et al., 1997; Chinn & Anderson, 1998; Lin et al., 2018) or in learning mathematics (Forman, 1987,1989, 2020).

The different social dimensions of knowledge construction

With the multiplication of learning interactions, attention has also shifted to the social nature of these interactions and the socially determined conditions for knowledge construction in cooperative discourse. For example, one trend based on the cooperative paradigm investigated the extent to which the realized interactions in learning processes organized in heterogeneous micro-groups are influenced by behavioral patterns, beliefs, views, and prejudices that govern them. Researchers have explored how power and status relations are inherited even through interpersonal interactions. Elisabeth Cohen (1984, 1986), who created the cooperative model of Complex Instruction, her colleague Rachel Lotan (Cohen & Lotan, 2014), and their colleagues were among the first to draw attention to the need to restructure the framework of interpersonal communication cooperatively (Lotan & Holthuis, 2021). In addition to positive interdependence, they pointed out that complementary, partner-based roles as social behavior patterns help to resolve inherited behaviors and constructively use interpersonal interactions, raising the quality of the learning relationship.

Another approach highlights the importance of involvement from the point of view of more effective knowledge construction. It is necessary to create a learning situation in which participants learn together not only because of the interdependence of tasks but also by tapping into their self-actualizing tendency (Rogers, 1965) during learning (Davidson, 1985, 2021; Sharan & Sharan, 1990; Sharan et al., 2013). That is, learning based on curiosity, mind-challenging questions, and achieving an academic and critical level of thinking became the focus of this approach. To this day, representatives of the cooperative paradigm, including Gillis (2021), constantly emphasize the need to support conscious knowledge construction processes in interpersonal learning interactions. It is worth incorporating elements that contribute to achieving a higher level of knowledge construction into learning tasks. In recent years, Gillis has presented evidence of simple structures and strategies that can be built into dialogic, interpersonal learning interactions and that promote knowledge construction at the academic level (Gillies, 2018, 2021).

From the above, it is evident that the constructivist approach is organically intertwined with the approaches presented by the cooperative paradigm. Furthermore, the paradigmatic discourse of cooperative learning opens up new dimensions of knowledge construction. It rebuilds the social forms of traditional learning interactions and designs communication for learning so that each participant is guaranteed a chance to learn effectively. This

paves the way for each student to develop individually and to mobilize and develop their intra- and interpersonal competencies. At the same time, it allows participants' cognitive abilities to unfold at a higher level.

Arató (2013, 2014) recognizes the paradigmatic significance of cooperative learning, which incorporates aspects of knowledge construction, and strongly focuses on the social environment of learning and the structures that regulate the learning-teaching process. Spencer Kagan (1990, 2021), who comes from situational psychology, highlights the essential importance of the structural approach in capturing the "new glasses" of the cooperative paradigm. Like Aronson (1972, 2021) and David and Roger Johnson (1999, 2021), Kagan's Structural Approach draws attention to the structures that define behavioral frameworks (KAGAN, 1990, 2021). Instead of the primarily hierarchical and exclusionary structures that traditionally govern classroom communication and activities, it draws attention to cooperative micro-structures that facilitate the participation of everyone.

The contribution of the cooperative learning paradigm to the constructivist approach in educational science: a post-structural shift

In Arató's (2013, 2014) interpretation, it is possible to understand the paradigmatic shift (KUHN, 1970) of cooperative learning by examining its structural aspect. In his view, cooperative learning does not follow the classical structural approach (e.g. MORENO, 1934) in its strategy, but it does use inputs that can be extracted by structural means. For example, it also builds on the sociometric characteristics of a given group (e.g. JOHNSON & JOHNSON, 1999). By incorporating the results of constructivist educational science, it does not simply focus on individuals' or on groups of students' social knowledge construction – that is, on the framework of the socially structured mind. Instead, cooperative learning also considers the social psychological, sociological, and historical aspects of social determinism in interpersonal interactions. It emphasizes the transformation of the social environment of knowledge construction as part of the constructivist approach. In essence, it investigates ways to structure the process of constructing knowledge in a manner that does not perpetuate exclusionary patterns of interaction between people (ARATÓ, 2015).

The strategy of cooperative learning is to move beyond exclusionary learning-teaching structures as a given condition and replace them with cooperative structures that enable everyone to learn more effectively. This is why Arató (2013, 2014) refers to the discourse of cooperative learning as a post-structural paradigm. By its intervention, it transcends the given, often exclusionary, segregating, and undemocratic social structures of learning, transforming the structure of social interaction itself. From the post-structuralist tradition, the paradigmatic nature of this approach can best be understood through deconstruction. It intervenes in the social framework and social conditions of knowledge construction. It breaks down existing learning structures by recommending the use of cooperative structures as an alternative. That is, it dismantles the undemocratic, exclusionary social environment by organizing cooperative structures in their place - building something new and more effective, thereby eroding previous structures. This approach and process are also described in deconstructivist theoretical discourse in philosophy, epistemology, and literary studies in the 1970s and 90s, which are now part of the constructivist tradition (see, for example, BERGER & LUCKMAN, 1966; GERGEN & THATCHENKERY, 1996).
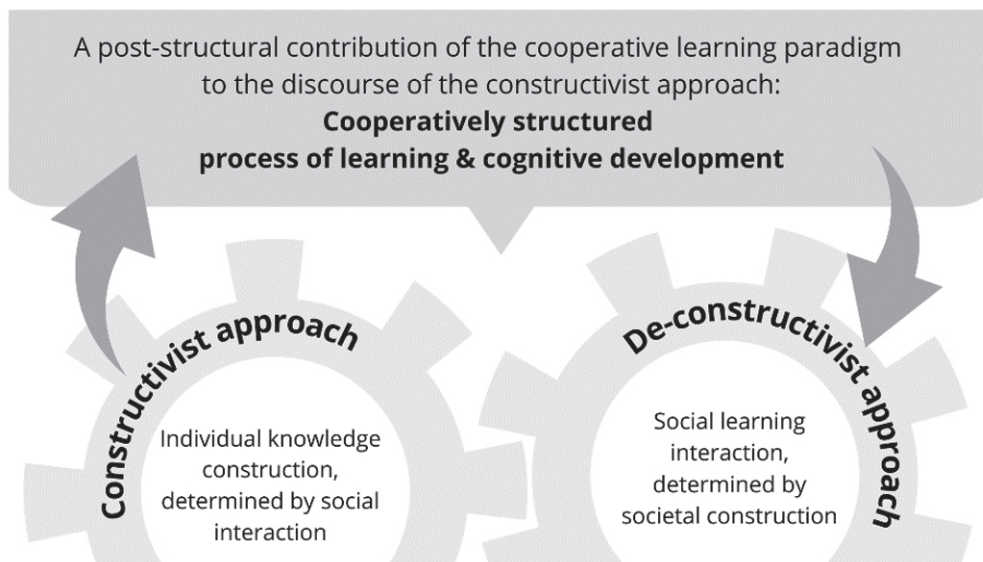
*Figure 1: A post-structural contribution of the cooperative learning paradigm
to the constructivist discourse of educational sciences*

The past half-century has demonstrated the validity of the constructivist approach and the cooperative paradigm built upon it, with thousands of studies in both discourses. Yet, the insights and practical concepts of both constructivism and cooperative learning have only marginally spread in worldwide pedagogical practice (e.g. GILLIES, 2018). Thus, it is appropriate to provide a brief overview that presents the possibilities for knowledge construction, making it easier for educators to integrate them into their daily pedagogical practice. These practical strategies can be easily recognized and interpreted by researchers studying knowledge construction methodologies and their effectiveness in their observations.

Cooperative learning has created the structural conditions for more effective learning in any subject. According to the experience of teaching and learning in both discourses, as we have seen above, elements and strategies that help to construct knowledge should be consciously incorporated into the planning, organization, monitoring, and assessment of learning and teaching.

In addition to restructuring the social environment, the cooperative learning discourse presents an essential principle, in accordance with the constructivist tradition, which is the need for the conscious development of cognitive skills (JOHNSON et al., 1984, 1999, 2021; KAGAN, 2014, 2021; GILLIES, 2008, 2018; GILLIES & KHAN, 2008; ARATÓ, 2013, 2014, 2017). This study aims to present several cooperative learning approaches to constructing knowledge, as well as practical pedagogical techniques developed over the past five decades.

Seven meaningful ways of constructing knowledge through cooperative learning

Seven practical approaches that use different tools for constructing meaningful knowledge are presented below. These are concrete strategies that educators can quickly adapt with the help of cooperative learning, not only in public education but also in higher education or workforce training. The first two simple procedures are based on the two cooperative principles mentioned earlier. We have already discussed the principles of parallel interaction and positive interdependence, so we will only briefly touch on them here.

Open, flexible, and interactive construction of knowledge

Just as the development of interactions between students has been an essential element of the social constructivist approach from its beginning to the present day (WERTSCH, 1979, 1980, 1992; PALINCSAR & BROWN, 1984; PALINCSAR, 1986, 1998; MERCER et al., 1999; MERCER, 2008; FROMAN & CAZDEN, 1985/2013; FORMAN, 1987, 1989, 2020; FORD & FORMAN, 2015), the intention to create a dialogue between students has also been a central, paradigmatic element of cooperative learning for decades. As seen in the first part of the study, interactive, dialogic learning and efforts to examine its effectiveness have emerged as an independent, significant research discourse in recent decades. We have examined how fostering learning dialogues between learners has become a defining feature of cooperative learning that paradigmatically transforms the learning environment.

One of the structural cooperative principles of transforming traditional behavioral frameworks is to ensure that all learners participate in as many learning interactions as possible in the available time. There are several approaches to exploring the importance of interactive, dialogic learning, as can be seen, for example, in the previously cited 2018 volume edited by Gillies. This volume also shows that the discourse of the social constructivist approach and of cooperative learning has become intertwined in past decades, as in the studies of several of the leading authors of the constructivist discourse: Forman (FORMAN-SHEEHAN, 2018); Palincsar (EASLEY & PALINCSAR, 2018); Anderson (LIN et al., 2018); - and their colleagues were published in the volume, alongside authors representing the cooperative discourse (THURSTON & COCKERILL, 2018; GILLIES, 2018). In the cooperative learning classroom, it is possible to shape the planned tasks and processes openly and flexibly, as the facilitator of learning can easily monitor and scaffold the knowledge construction processes through the learners' interactions and dialogues (SHARAN & SHARAN, 2021; JOHNSON & JOHNSON, 2021; Arató, 2013, 2014). As mentioned before, the teacher needs to have a broad repertoire of cooperative activities to respond appropriately to the given group of students, the given subject context, and the learning environment (ALEXANDER, 2018). Arató (2013, 2014) articulates the need for a cooperative paradigm to create flexible and open structures as an independent principle fundamental in the cooperative discourse. From what we have seen so far, it has become clear to the reader that interactive, inclusive learning dialogues are an essential part of efficient, effective, and equitable knowledge construction processes.

Positively interdependent constructions of knowledge

Another vital principle of the cooperative paradigm is the principle of positive or mutual interdependence (JOHNSON & JOHNSON, 1999, 2021; ARONSON, 1972, 2021) or the principle of constructive and encouraging interdependence (ARATÓ, 2013, 2017; HUBER & REYNOLDS,

2014). It is advisable to design learning tasks so that group members can carry them out interdependently. Personality traits that are mobilized or preferred by those involved in group learning depend on the task's goal structures.

Several researchers studied the various aspects of the development of cooperative learning processes. Kurt Lewin and his students explored the socially defined but dynamic nature of personality. Similarly, Deutsch (1949, 1962, 1985, 2006), worked on the significance of the goal structure of interdependence, and Deutch's students David and Roger Johnson (1974, 1999, 2009, 2021), who represents another well-known school of cooperative learning, highlight. There is a need to develop learning structures that call for group members to work interdependently, rather than having them compete or learn individually. Aronson, following Lewin's student Festinger as well as Allport (1955), follows a similar approach when he and his colleagues developed the cooperative structure The Jigsaw Classroom (ARONSON et al., 1978; ARONSON, 1972, 2021). The Jigsaw Classroom was created for desegregated classes to eliminate students' prejudices by designing a cognitively dissonant situation in which [despite their prejudices] enabled them to learn together. Transforming traditional learning interaction through cooperative structures optimizes knowledge construction, as it gives everyone a chance to learn through face-to-face interaction. Cooperative learning allows teachers to provide a learning situation for each student, based on mutual interdependence that encourages students to build knowledge together.

Synergistic knowledge construction

Synergistic knowledge construction is one of the fundamental cooperative learning strategies. The paradigmatic exemplar of the cooperative discourse (Arató, 2013, 2014), the Jigsaw Classroom, cited above, is one of the crucial strategies. It creates interdependent parts of learning material, like a jigsaw puzzle, by teaching each other. "Jigsaw puzzle" is a very perceptive term; it is also expedient to use another metaphor. If we imagine the assembly of puzzle pieces as synergy, then it will be easier to understand how the whole will be more than the sum of its parts. The participants in learning do not stack ready-made building blocks but rather interact back and forth during teaching one another. "Who teaches learns twice!" explains the synergistic relationships in cooperative discourse (JACOBS et al., 2022). While learning and teaching one another, knowledge construction by better prepared and less prepared learners is more malleable during processing, absorbing difficult issues and even connections, practices, and knowledge that heretofore seemed opaque.

The extent to which these components are not separated is further demonstrated by the jigsaw structure in which they must interpret the same text or phenomenon, but each from a different point of view. The goal is for everyone to provide constructive responses to learning challenges from a group of four, all four aspects, meaning that everyone learns to apply all four aspects. Here, understanding the aspects, interpreting them together, and connecting them with the practical elements also turns out differently than simply putting out a puzzle consisting of rigid pieces. Sometimes, it's only one clear aspect that comes out of the aspects. Other times it's someone else's suggestion that makes all the aspects clear to someone until all four of them can apply the learned aspects in a relevant and constructive way at the expected level of performance. The level of performance of the complexity of thinking can be well-tracked in any subject context, for example, using the SOLO taxonomy, which is also used in cooperative discourse (GILLIES, 2021), or the Argumentation Rating Tool (WILKINSON et al., 2017; REZNITSKAYA & WILKINSON, 2021).

It follows from the above that simple, jigsaw structures based on the principle of constructive and encouraging interdependence and parallel interactions - anyone, in any

learning process, can open channels of learning synergy. The term constructive interde-pendence is intended to refer precisely to the synergistic nature of knowledge construction in the cooperative literature (Arató, 2013, 2014). Teachers design synergistic elements in the learning process that will surely be part of a common horizon of interpretation and learning when coupled with individual responsibility. These can be different parts of ma-terial, topics, interconnected tasks, points of view, interpretive frameworks, experimental and practical procedures, etc. Even initial research has shown and has remained so for the past five decades that on-task time in a given time frame increases exponentially with the help of sequential tasks (Johnson & Johnson, 1989, 2021). The learners report that the par-ticipants who are ahead of the curve, as well as those who are lagging, are more like to go to school because, with the help of others, they learn more thoroughly and effectively. Even if someone was an excellent student before, their success increases. Even if they have lagged, they start learning more effectively. An essential source of this is the synergisti-cally designed knowledge construction of the peer community of learners guaranteed by cooperative structures.

Synoptic knowledge construction

An essential element of knowledge construction is the use of scientifically proven frame-works. This means that teachers and pupils consider common, scientifically justified think-ing frameworks. When the facilitators of learning seek to make learning more effective by broadening the repertoire of thinking abilities set in motion in everyday learning-teaching practice, they can follow clear goals with their students using a common framework. This idea was the basis of Bloom's formative evaluation, a cognitivist or constructivist turn in evaluation (Scriven, 1967), which later spread as a formative assessment, precisely at Bloom's suggestion (1969). In this approach, it is also necessary to develop an assessment methodology linked to performance evaluation that will help students understand how to perform better and what to do differently to be more effective in learning. One such guide was the simple, six-element Bloom's taxonomy (1956; Anderson, 2001), which presents cognitive domains according to the objectives of learning. It can be followed by both the teacher and the students in their questions, learning instructions, or assignments because it is simple and contains only six aspects. In the meantime, they strive to explore what to learn at every step with the help of all six Bloom cognitive domains. If they practice the use of thinking skills in a vast repertoire every day, they can all achieve higher performance, regardless of their sociocultural background (see this in the cooperative discourse Kagan, 2014 or Gillies, 2021, or in significant research independent of the cooperative paradigm, Wenglinsky, 2000, 2002). Synoptically coordinated knowledge construction takes place through the questions, instructions, and specific learning activities formulated based on the Bloom framework.

A similar framework is when they follow the appeal of as wide a range of Gardnerian intelligences as possible (Gardner, 1984) as a common framework in the discourse of cooperative learning (Cohen & Lotan, 2014, Kagan & Kagan, 1998, Jacobs et al., 2022), or when they follow some process design framework (Smith et al., 2005, ByBee, 2014, 2015, Gillies, 2021). Similarly, educators can use a common framework for subject content. For example, when each student uses six important biological aspects describing representatives of the animal kingdom to present their favorite animal of their choice, each child walks their individual learning path and performs a synoptically identical knowledge construct with the others. An essential feature of synoptic constructs is that learning performances can be easily compared, with participants able to help validate fundamental aspects in

contexts other than those they like, in the example above, by helping to describe the animals of others. It is precisely the synoptic knowledge construction that helps to strengthen in the learners a multiperspective and a divergent set of thinking necessary for problem-solving. Synoptic frameworks promote the comparability of diverse content, comparative processing of the content, and the practice of complex thinking skills. The brain needs a clear framework and predictability for effective learning. Frameworks with a small number of items consider that the working memory can effectively process just a small number of inputs at once (Cowan, 2014). If we want to use the brain capable of learning optimally, we will help the working memory with 3-7 elements of synoptic frameworks at each stage of learning activities. The 3-7 element frameworks help construct knowledge in just one lesson, but they can also be a guide for a semester-long period with many learning activities.

Multicontextual knowledge construction

Learning activities that build on each other in parallel interaction and develop positive interdependence are an excellent framework for multicontextual knowledge construction. They help to improve learners' critical and problem-solving skills, not just from a metacognitive perspective but also in terms of long-term memory improvement (Tricot & Sweller, 2014). We have already touched on this issue when discussing synoptically organized learning, where learners think through the same summary in different contexts, for example, when studying about different animals. Multicontextuality is one of the most critical forms of metacognitive knowledge construction. The most striking example is when the same natural phenomenon is simultaneously studied in physical, chemical, mathematical, and geographical-social contexts (e.g., the phenomenon of acid rain). In this case, we use a transdisciplinary strategy to form multicontextual frameworks to construct knowledge, in which various sciences raise a real problem, a stimulating question. The multicontextual learning-teaching practices of STEM or STEAM, for example, are based on this approach (Prince et al., 2020; Fenyvesi et al., 2017).

In a cooperative framework, it is easy to create a structural guarantee for multicontextual learning. As in a Jigsaw structure based on four-member groups, an "expert" will be responsible for each sub-group's area to ensure all four areas are followed understood. Thus, professional frameworks, tasks, data knowledge, procedures-practices, etc., that help with processing can be continuously added to all four areas. It means that learners will constantly scrutinize at least four contexts at every step of learning. Responsibility for contexts is exchanged between group members until each of them can independently look at a learned or even new phenomenon from the point of view of each of the four scientific fields.

Similarly, educators can imagine multicontextual frameworks in the humanities. In history, for example, one of the problems with lecture-based teaching is that it traditionally follows a linear narrative, so students often need help seeing the connections and recognizing events that take place at the same time. A topic organized in the same cooperative Jigsaw framework for groups of four, e.g., WWII, can be understood and learned more deeply and in a meaningful context if students delve into the topics and contexts of a given era with the help of parallel synoptic frameworks. The use of cooperative structures also helps, with emphasis on constructive and encouraging interdependence (everyone needs high-quality knowledge in all parts to perform), as well as the principles of personal responsibility and individual accountability (everyone having their own set of criteria within a specific topic, for which they are responsible, not only in their "home" group but through their group throughout the class).

For example, if each group researches a specific country or social group, the stories of 8-10 of the most important "actors" (countries or social groups) can be processed at once. That is, each student learns the topic from several aspects, in several contexts, even if, in the beginning, they progress only in small steps. Thus, for a specific context of each topic - be it, for example, "the role of France in WWII" or the "position of women in WWII" there will be four experts who form a micro-group. It means that in the micro-group, they can follow four different frameworks on the same topic. For example, they can pursue issues such as political power, socio-economic, cultural-educational aspects, and oral history. If each team follows these aspects in their topic context, they can learn their topic and the topic of others, that is, the entire curriculum, in a multicontextual context. If we measure the performance of the whole student group from the complete material, it will also reveal which experts, or entire expert groups (topic or aspect experts), need to strengthen their topic and professional aspects in the given group or even the whole class in the next stage of learning.

However, the fundamental advantage of multicontextual knowledge construction is that students are to approach a particular issue in a multifaceted, divergent way while at the same time able to follow convergently, scientifically relevant aspects, interpretations, and procedures in these different contexts. One of the components of critical thinking is the ability to engage in metacognitive thinking activities. A critical-reflective exit from a given context is a good example. By stepping out of their context, like in the examples above, examining a topic from different aspects within the same micro-group and in different contexts during the intergroup communication, they can validate and evaluate what they learned in other, broader, or different contexts. The most interesting aspect of multicontextual learning-teaching processes is how to use what has been discovered in different contexts in terms of constructive interpretation and learning, as well as how to deepen understanding by examining the validity of what learners comprehended in other contexts.

Positive interference in knowledge construction

Another metaphor that is worth reconsidering in terms of constructing knowledge is the construction metaphor itself. The problem with this analogy is that it conjures up images of building blocks, whereas in reality, the metaphor of interference seems more accurate. Just as positive interference can amplify waves in physics, collaboration and discussion among learners can amplify the acquisition and retention of knowledge, leading to deeper learning and better outcomes. This phenomenon occurs within the framework of knowledge construction, where multiple waves, each shaping the other, combine to form deep understanding, rather than fitting together like building blocks or jigsaw puzzle pieces.

This is particularly noticeable when it comes to group roles. Even if group members create interdependent, complementary roles that cover the necessary skills for well-oiled group operation, all the skills, aspects, and procedures addressed will not come together. Instead, they arrive in waves, aligning with each other, constructively interfering with others' roles and contributions to the group's work. In knowledge construction, the positive interference of behaviors can amplify the understanding and insights that emerge from collaborative learning experiences.

For instance, the Encourager may be responsible for ensuring equal participation. Initially, the person assigned to this role may not understand its value, such as using Rally Robin, even though they apply this structure repeatedly. However, as the Encourager interacts with other group members, they may realize the value of this tool and use it to promote equal participation. This understanding of how to fulfill the role, for example, by employing Rally Robin, develops through repeated social interactions.

As group members become more proficient in their roles, they change roles to ensure that each member has an opportunity to practice different behaviors and learn new social behavior patterns. Over time, role knowledge constructed through social activity develops into deeper understanding of appropriate social behavior during group work.

Therefore, it is advisable to incorporate functions, patterns of behavior, aspects, procedures, etc., during knowledge construction, which, with their continuous presence, build knowledge through constantly rising waves, showing positive interference with the necessary behaviors, aspects that can be scientifically justified, etc.

Action-based knowledge construction

An additional way to construct knowledge is when group members engage in actual actions. When they step out of the classroom into the real world. This can be achieved through forming a learning community that involves knowledge elements of the social environment of the classroom members like families and neighborhood (McCaleb, 1995). Or by creating a community of practice (Wenger et al., 2002), where learning interactions are carried out specifically for the sake of practice.

Kurt Lewin, who defined the cooperative paradigm, was also the founder of action research (Lewin, 1946, 1947), seeing the future direction of scientific research in collaborative research communities focused on practice. Similarly, knowledge construction takes learning to the next level when a community of students steps outside the classroom and participates actively in reality. Approaches such as project-based learning (Dewey, 1900, 1918; Kilpatrick, 1918), inquiry-based learning (Pedaste et al., 2015; Gillies, 2021), or place-based learning (Davidson-Hunt & O'Flaherty, 2007; Gruenewald & Smith, 2007; Johnson, 2012) follow a similar approach to knowledge construction. This approach also relates to Kolb's discovery of the experimental learning cycle for effective learning (1984), which is easily implemented in cooperatively structured learning processes (Smith et al., 2005; Gillies, 2021).

An essential element of action-based knowledge construction is that it is based on participants' questions. For example, in the above example, when students learn about the phenomenon of acid rain in a multicontextual process, it is easily associated with social learning actions that become real. Learners can formulate leading questions such as "What can we do about the phenomenon of acid rain? What are emitters of harmful substances in our narrower environment doing to prevent this phenomenon? How to draw attention to the phenomenon and what needs to be done?" When participants implement the concrete, creative, social, or experimental activities they plan, they move to a higher level of knowledge construction.

An excellent example of action-based or project-based knowledge construction is the Swiss Ikarus project (http://www.projekt-ikarus.ch), which was born out of 10-year-old students bombarding their teachers with questions about what makes the sky blue. They wanted to fly up to the sky to find out what makes it blue. To this end, for one month they learned a great deal in the fields of physics, geography, astronomy, meteorology, and mathematics, constantly experimenting to directly observe the phenomenon of refraction of light in the atmosphere. At the end of the project, each student sent their favorite Lego figure into space using meteorological balloons, a mini-camera, and a GPS tracker. Together, they analyzed the evidence collected after the balloons reached the stratosphere border and returned to earth with the video footage.

The contribution of cooperative practice
to the social transformation of knowledge construction

The following table summarizes the practical concepts and procedures of the cooperative learning paradigm outlined above and how they help optimize the social conditions of knowledge construction. Constructivist educational science and its interactive and dialogue-based ideas have led to several practical approaches, models, and concrete practices for pedagogical practice that positively influence knowledge construction for all learners. Cooperative learning incorporates the results of constructivist approaches into practice (see KAGAN, 2021; GILLIES, 2019, 2021; JACOBS et al., 2022) and over the past fifty years has confirmed a paradigmatically new practice, transforming the social framework of knowledge construction (SHARAN, 1984; DAVIDSON, 2021).

Seven typical paths of knowledge construction in the practice of cooperative learning	Transforming the social framework of knowledge construction for guaranteed achievement
Parallel interaction-based knowledge construction	Structurally guaranteed increased personal time, space, and attention for each student in classroom learning interactions
Positive interdependence-based knowledge construction	Structurally guaranteed personal involvement, and constructive participation in heterogeneous micro-groups
Synergistic knowledge construction	Structurally guaranteed integration of synergistically interdependent knowledge elements
Synoptic knowledge construction	Structurally guaranteed conscious, processual, and comparable frameworks based on proven models for everyone
Multicontextual knowledge construction	Structurally guaranteed proficiency in multiperspective, metacognitive, reflective, and critical knowledge acquisition activities
Positive interference of knowledge construction	Structurally guaranteed flow process constructions for all participants
Action-based knowledge construction	Structurally guaranteed equal access and participation in activities and action-based learning processes

Table 1: Seven ways of knowledge construction through cooperative learning

The above practical elements of cooperative knowledge construction procedures ensure that each participant learns effectively. Participants practice and acquire knowledge constructing behavioral patterns and routines through a cooperatively structured learning processes. Educators can construct, not only the elements of knowledge related to scientific approaches but also knowledge related to everyday social interaction, thus shedding their prejudices and approaching the values of a more democratic social existence.

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