MEASURING STUDENT SUCCESS SKILLS: A REVIEW OF THE LITERATURE ON COLLABORATION

March 31, 2020

21st CENTURY SUCCESS SKILLS

Carla Evans, Ph.D.
National Center for the Improvement of Educational Assessment

Center for Assessment

www.nciea.org

TABLE OF CONTENTS

INTRODUCTION 3

DEFINITIONS 4

- What is Collaboration? 4
- Are Collaboration Skills Generic or Discipline-Specific? 9
- What is the Relationship Between Collaboration and Other Success Skill Concepts? 9

DEVELOPMENT 10

- How Does Collaboration Develop Over Time? 10

INSTRUCTION 11

- What Are Some Instructional Approaches to Teaching Collaboration? ... 11
- What Do We Know About the Effects of Instruction on the Development of Collaboration Skills and Student Achievement? 14

MEASUREMENT/ASSESSMENT 15

- How is Collaboration Typically Measured or Assessed? 15
- What are the Measurement/Assessment Issues Related to Collaboration? 15
- What are the Implications of Research for Assessment Design and Use? 18

CONCLUSION 21

REFERENCES 22

APPENDIX A 27

1. Center for Assessment completed this work on behalf of PBLWorks (Buck Institute for Education) in its effort to provide tools and resources to school and district partners as they assess student success skill performance in Gold Standard Project Based Learning.

2. I acknowledge the terrific feedback on previous drafts from my colleagues at the Center for Assessment. Any errors and omissions are my own.

3. This work is licensed under the Creative Commons Attribution 4.0 International License (CC BY). To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/.

4. Evans, C. M. (2020). *Measuring student success skills: A review of the literature on collaboration.* Dover, NH: National Center for the Improvement of Educational Assessment.

MEASURING STUDENT SUCCESS SKILLS: A REVIEW OF THE LITERATURE ON COLLABORATION

INTRODUCTION

What children can do together today, they can do alone tomorrow. (Vygotsky, 1962)

There is a growing interest in conceptualizing, defining, and assessing what are often called 21st century skills (Care, Kim, Vista, & Anderson, 2018; NRC, 2011; Soland, Hamilton, & Stecher, 2013) or deeper learning competencies (Fullan, Quinn, & McEachen, 2017; McEachen & Kane, 2019; Mehta & Fine, 2019; Sergis & Sampson, 2019). These student success skills are valued for many reasons, including links to both proximal outcomes, such as increased student achievement and college/career readiness (Conley, 2007; Mehta & Fine, 2019), and more distal outcomes such as workforce productivity and civic life participation (NRC, 2008; OECD, 2018b, 2018a, 2019).

The list of important student success skills varies slightly among conceptualizations, but most lists include critical thinking, communication, collaboration, creativity, and self-direction in one form or another (Lai & Viering, 2012; Lench, Fukuda, & Anderson, 2015; Rios, Ling, Pugh, Becker, & Bacall, 2020). Numerous frameworks attempt to categorize these knowledge, skills, and dispositions into logical groupings for teaching and assessment purposes. Three common examples of frameworks are the Partnership for 21st Century Learning (P21, 2019), National Research Council (NRC, 2012), and Assessment and Teaching of 21st Century Skills (ATC21S, 2014; Binkley et al., 2012).

The Partnership for 21st Century Learning Frameworks (P21, 2019) divide student success skills into four categories: mastery of key subjects; learning and innovation skills (e.g., collaboration, communication, creativity and innovation, critical thinking and problem solving); information, media and technology skills; and life and career skills (e.g., self-direction). The National Research Council (NRC, 2012) did not create a separate category for information, media, and technology skills, using three categories instead: cognitive competencies (e.g., mastery of academic core content, critical thinking, etc.), interpersonal competencies (e.g., collaboration and communication), and intrapersonal competencies (e.g., self-direction). The ATC21S framework defines the 21st century skills in four broad categories: ways of thinking, ways of working, tools for working, and ways of living in the world (Binkley et al., 2012). The ATC21S framework uses the acronym KSAVE—knowledge, skills, attitudes, values, and ethics—to emphasize that there are cross-cutting components within each of the four broad categories.

Educators have long used collaborative approaches to teaching and assessing students. Constructivist and socio-cultural learning theories expound how students construct meaning and learn in social contexts. More recently, educators and policymakers have identified the ability to collaborate as

More recently, educators and policymakers have identified the ability to collaborate as an important outcome in its own right rather than merely a means to teach and assess traditional academic content.

an important outcome in its own right rather than merely a means to teach and assess traditional academic content. We see this emphasis reflected in portraits of a graduate in many states (e.g., South Carolina and Virginia) or districts (e.g., Shrewsbury, MA) whereby parents, community members, and educators provide input into the types of knowledge, skills, and dispositions they want to see reflected in their high school graduates.

Notwithstanding the growing interest in collaboration as one critical student success skill, collaboration itself is conceptually vague. While the literature reveals many definitions and ways of operationalizing collaboration, the question nonetheless remains: What does it mean to collaborate, and how can collaboration be taught and assessed within schools?

The purpose of this literature review is to explore the conceptualizations, definitions, and understandings in the research literature related to collaboration. Key initial questions include: What is collaboration? How is collaboration related to other success skill concepts? And to what extent does collaboration develop over time? This foundational information will then be used to examine (a) instructional approaches to promote collaboration, (b) benefits of collaboration on valued student outcomes such as student learning, and (c) ways teachers can collect evidence that reveals the benefits of student collaborative outcomes using student artifacts and other appropriate measures.

DEFINITIONS

What is Collaboration?

We find collaboration in every discipline and field (Greenwald & Zukoski, 2018; Thomson, Perry, & Miller, 2007), and it is relevant to all ages (Tomasello & Hamann, 2012). This review focuses on definitions and content relevant to K-12 school settings.

The literature is clear that giving students opportunities to work together is not necessarily the same thing as having them collaborate.

Collaboration lacks a clear, agreed-upon definition and operationalization (Dillenbourg, 1999; Lai, 2011), although the literature is clear that giving students opportunities to work together is not necessarily the same thing as having them collaborate (Rotherham & Willingham, 2010). Group work is often a simple division of labor or "free rider" experience where students divide up the tasks and rely on the most competent group member to drive the group product (Salomon & Gloverson, 1989). Genuine collaboration, in contrast, requires distinct social and cognitive processes.

To add to the lack of conceptual clarity, many terms often are used synonymously with collaboration. Among them are:

- collaborative activity or skills (Child & Shaw, 2016; Ladd et al., 2014; Mercer, 1996; Zillmer & Kuhn, 2018);
- group collaboration (Webb, 1993, 1995; Webb, Nemer, Chizhik, & Sugrue, 1998);
- collaborative learning (Dillenbourg, 1999; Kuhn, 2015; van Boxtel, van der Linden, & Kanselaar, 2000);
- collaborative problem solving (Care, Scoular, & Griffin, 2016; Hao, Liu, Kyllonen, Flor, & von Davier, 2019; OECD, 2017; Roschelle & Teasley, 1995; Sears & Reagin, 2013; von Davier & Halpin, 2013);
- cooperation (Dillenbourg, 1999);
- cooperative learning or inquiry (Gillies, Nichols, Burgh, & Haynes, 2014; Johnson & Johnson, 2002; Johnson & Johnson, 1994);
- and teamwork (French, Gotch, Immekus, & Beaver, 2016; NRC, 2012; Zhuang, MacCann, Wang, Liu, & Roberts, 2008).

It is important to clarify whether collaboration is viewed as a means to an end—such that student learning of content, not collaboration, is the desired outcome (collaboration as outcome)—or, rather, collaboration is viewed as an end in itself (collaboration as process). The research literature on collaboration reflects both views, although the dominant paradigm historically has been the former: collaboration as a means to enhance student acquisition of content knowledge and other important cognitive skills, like critical thinking and problem solving (Kuhn, 2015). In this view, students work in groups to support more effective learning of academic knowledge and skills. It is left to the teacher to decide whether the intellectual outcomes of interest are at the individual or group level. Collaboration as outcome implies that the final product related to content and group productivity takes precedence over the means to achieve the goal (Child & Shaw, 2016). Therefore, dividing the work among group members to complete independently and relying on the work of the highest achieving student (or other undesirable learning practices) may be more incentivized (Barron, 2003; Webb, 1995).

It is important to clarify whether collaboration is viewed as a means to an end—such that student learning of content, not collaboration, is the desired outcome (collaboration as *outcome*)—or, rather, collaboration is viewed as an end in itself (collaboration as *process*).

Collaboration as process, on the other hand, views collaboration as a domain-general skill that is important in its own right for work and life in society. Kuhn (2015) associates this with the 21st century skills movement. In this view, students work in groups to improve their ability to work with others, and the quality of student interactions therefore should be the focus of teaching and learning. To be sure, intellectual gain and increased academic content knowledge and skill could be a bi- or co-product of collaborative activity, but this is not the focus either of instruction or of assessment related to collaboration. Rather, the focus is on the nature and quality of the collaborative activity and the interactions among group members.

Collaborative State and Types of Interactions Among Students

High-quality interactions among students is sometimes referred to in the literature as the collaborative state—the cognitive and social knowledge, skills, and dispositions required to truly collaborate (Child & Shaw, 2016, 2018; Dillenbourg, 1999). The collaborative state requires social interdependence, communication, negotiation, reflection, and task management. Social interdependence requires certain types of interactions to be promoted in groups.

Johnson and Johnson (1994) clarify three ways students can interact with each other. Table 1 summarizes these three approaches: (a) students believe they "sink or swim" together, as they can reach their goals only if other students in the group also reach their goals (promotive interaction: collaborative); (b) students believe they can obtain their goals only if other students in the group fail to meet their goals (oppositional interaction: competitive); and (c) students believe their goal achievement is unrelated to what other students in the group do (no interaction: individualistic). The more social interdependence required in a collaborative learning activity or project, the more promotive interaction should occur. Individualistic interaction among students in a group occurs more often when the learning activity or task requires a simple division of labor.

Table 1.
Three Types of Interaction Among Students

Promotive Interaction: Collaborative	Oppositional Interaction: Competitive	No Interaction: Individualistic
Individuals believe they can reach their goals only if the other individuals in the situation also reach their goals.	Individuals believe they can obtain their goals only if the other individuals in the situation fail to obtain their goals.	Individuals believe the achievement of their goals is unrelated to what other individuals in the situation do.

Collaboration differs from cooperation in the types of student interactions we see occurring (Dillenbourg, 1999). In cooperative learning activities, students typically will divide up the work, individually complete tasks, and then assemble their respective contributions. Consequently, cooperation does not require collaboration or promotive interaction. This is not to say that division of labor cannot occur within collaborative learning activities; coordination of group thinking and work processes still occurs throughout (Dillenbourg, 1999). In contrast to individuals working alone, cooperative learning may lead to better group performance outcomes simply because the division of labor allows more to be accomplished. On the other hand, cooperative learning (or poorly designed collaborative learning activities) may lead to more "free riding" or "social loafing" behaviors where individuals do not contribute equally toward the group goal (Barron, 2003; Salomon & Gloverson, 1989; Sears & Reagin, 2013). This often frustrates students working in groups.

Collaboration differs from cooperation in the types of student interactions we see occurring.

Towards a Definition

There are many definitions of collaboration in the research literature. Table 2 provides an overview of the main definitions in the K-12 research literature. Most are general, but some are specific to collaborative problem solving, as one context in which collaboration can occur (e.g., OECD, 2013, 2017).

Table 2.
Definitions of Collaboration

Source	Definition
(Care et al., 2018)	*Collaboration occurs when meeting a goal requires more than what any one individual is able to manage alone and therefore needs to pool resources with others.*
(Dillenbourg, 1999)	*Collaborative learning describes a situation in which particular forms of interaction are expected to occur, which would trigger learning mechanisms.*
(Hesse, Care, Buder, Sassenberg, & Griffin, 2015)	*Collaborative problem solving is a joint activity where two or more people work together to contribute resources they alone control, to progress through a series of cognitive states that involve collection and analysis of information and the formulation of a hypothesis that they jointly set out to test.*

Table 2.
Definitions of Collaboration (continued)

Source	Definition
(Lench et al., 2015)	*Collaboration is an individual's capacity to work with other people in a process that requires interdependence to solve a problem, achieve a goal, or complete a task.*
(Littleton, 2011)	*Collaboration is mutual engagement in a coordinated effort in which group performance and/or subsequent individual performance exceeds that which any member brought to the group.*
(OECD, 2013, 2017)	*Collaborative problem solving competency is the capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and effort required to come to a solution and pooling their knowledge, skills, and efforts to reach that solution.*
(Roschelle & Teasley, 1995)	*Collaboration is coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem.*
(Soland et al., 2013)	*Collaboration can be thought of as communication plus additional competencies related to conflict resolution, decision making, problem solving, and negotiation.*

There are three fundamental aspects differentiating collaboration from other related activities, such as cooperation and coordination (Child & Shaw, 2018; Lai, 2011):

1. Two or more students working interdependently
2. who participate in genuine joint activity (e.g., solve a problem, complete a task, design a product, etc.)
3. by pooling their knowledge, skills, and efforts.

There are three fundamental aspects differentiating collaboration from other related activities, such as cooperation and coordination.

Genuine joint activity implies authentic contexts and, further, encourages students to pool their knowledge and skills and to work interdependently rather than operate on parallel, individualistic tracks. The challenge in creating collaborative structures is to develop ways to increase the odds that some type of promotive interaction or collaborative activity will occur.

As Dillenbourg (1999) argues, simply putting students into collaborative learning groups will not necessarily bring about the expected interactions that trigger learning mechanisms (e.g., induction, deduction, compilation) or cognitive mechanisms (e.g., knowledge elicitation, internalization, reduced cognitive load). To increase the probability that collaboration, as defined above, occurs, Dillenbourg advises that instruction and assessment should focus on four related factors: *type of interactions* (negotiation, conflict resolution), *requirements of the situation for more/less collaboration* (interdependence, interactivity), *effects of collaboration on individuals and group products* (e.g., increased learning, reasoning, justification, explanation, and quality of final product), and enabled *cognitive processes* (e.g., perspective taking, argumentation, justification, explanation, analysis). These four markers of collaborative learning require teachers to (a)

carefully set up the initial conditions, (b) assign students specific roles or jobs in the group, (c) scaffold productive interaction by including interaction rules, and (d) monitor and regulate the interactions.

Toward an Operationalized Definition

While it is critical to define collaboration, it is essential for instruction and assessment purposes that the definition also is operationalized. To operationalize means to take a concept, such as collaboration, and specify what is observable and therefore measurable.

The way in which collaboration is operationalized depends on several factors. First, what is the intended purpose and use of the operationalization? Is it to teach and assess the collaborative process (quality of student interactions), or is it to evaluate the outcomes of collaboration (quality of student/group products)? Regarding the latter, collaboration is a means to an end—the end being improved student content knowledge—so typical academic performance measures could be used.

When teaching and assessing the collaborative process, however, one should examine the extent to which the collaborative action or behavior of interest is observable or reportable. What does genuine collaboration look, sound, and feel like in the classroom? What can teachers, students, and peers observe? What does genuine collaboration expect of students that might not be directly observable, such as mental processes, but could be reported by students if prompted? What constraints are present due to the intended assessment design and measurement requirements (e.g., large-scale computer administered and machine scored assessment designs may require a different operationalization than classroom-based assessments)?

Appendix A reports the operational definitions of collaboration found in the research literature and how these definitions relate to 21st century skill frameworks or assessments in use. Some definitions are specific to collaborative problem solving as assessed via a computer simulation or technology-enhanced assessment in large-scale settings (e.g., OECD, 2017; Zhuang et al., 2018), whereas others are intentionally broader and attempt to delineate the cognitive and social skills involved in collaboration (e.g., Child & Shaw, 2016, 2018).

Notwithstanding the variety of operational definitions of collaboration found in the literature, several collaboration skills are consistently repeated across sources.

Notwithstanding the variety of operational definitions of collaboration found in the literature, several collaboration skills are consistently repeated across sources. Appendix A uses color coding to highlight where these collaboration skills surface in different sources. These collaboration skills include:

1. **Plan and make group decisions:** decide with the group how best to manage and complete the task or project, work with the group to assign roles or tasks, use negotiation or conflict-resolution skills as necessary to plan and make group decisions.
2. **Communicate about thinking with the group:** seek clarity about others' thinking, respectfully express how thinking makes sense or is lacking in some way, solicit alternative perspectives and input from all group members, elaborate on the explanations of others.
3. **Contribute resources, ideas, and efforts and support group members:** contribute ideas, efforts and resources; support group members as needed; take responsibility for task assignments and work quality; provide feedback on the work of others.
4. **Monitor, reflect, and adapt individual and group processes to benefit the group:** reflect on individual and group progress and processes, work with team to adjust group efforts to meet goal, adapt individual and/or group processes to benefit the group, check in with group members about progress.

Are Collaboration Skills Generic or Discipline-Specific?

The answer to this question is simple from one perspective, but more complicated from another. Collaboration skills, such as (a) planning and making group decisions, (b) communicating about thinking with the group, (c) contributing resources, ideas, and efforts and supporting group members, and (d) monitoring, reflecting, and adapting individual and group processes to benefit the group, are a generic set of knowledge and skills not tied to any content area or discipline. For example, the knowledge and skills related to planning and making group decisions do not depend on whether the collaboration occurs in a science, math, or English class. This is how collaboration differs from success skills such as critical thinking and creativity, where the knowledge and skills are more domain specific.

However, it is difficult to meaningfully engage in collaborative tasks without having discipline-specific content knowledge (Lai, DiCerbo, & Foltz, 2017; Rotherham & Willingham, 2010). For example, students can contribute much more effectively in collaborative tasks—offering resources, ideas, and efforts—when they have at least some content knowledge. Without such knowledge, students act more as observer than as true collaborator.

Students can contribute much more effectively in collaborative tasks—offering resources, ideas, and efforts—when they have at least some content knowledge. Without such knowledge, students act more as observer than as true collaborator.

Given both the generic- and discipline-specific nature of collaboration, assessments intended to gather evidence of students' knowledge, skills, and dispositions related to collaboration should sample from multiple content areas and potentially be expressed as a profile reflecting students' relative strengths and weaknesses as inseparable from disciplinary knowledge and skills (Lai & Viering, 2012).

What is the Relationship Between Collaboration and Other Success Skill Concepts?

Student success skills can be categorized into three competencies: cognitive, intrapersonal, and interpersonal (NRC, 2012). Collaboration is an interpersonal competency along with communication and leadership. Collaboration requires communication because it is impossible to collaborate without some form of communication (Lench et al., 2015). Placing success skills in three categories does not mean these skill clusters are independent or mutually exclusive (NRC, 2011). Rather, it is impossible to collaborate without cognition or self-regulation.

Lai and Viering (2012) synthesized the research evidence pertaining to several student success skills—critical thinking, creativity, collaboration, metacognition and motivation—and how they interrelate. These authors found that collaborative learning may stimulate critical and creative thinking. For example, working with others will stimulate cognitive dissonance and increase the number and quality of ideas generated. Thinking is often triggered by the ideas of others, and different perspectives in a group can lead to the consideration of innovative or alternative ways of thinking. Collaboration may also promote metacognition—thinking about thinking—when individuals are prompted to provide elaborated explanations and thereby make their reasoning visible. Further, working collaboratively with peers can improve student motivation to learn because of peer encouragement, peer modeling, and the novelty of the collaborative learning task. Collaborative learning is also related to self-regulated learning (NRC, 2012).

Collaboration is an interpersonal competency along with communication and leadership.

Self-regulated learners know when to seek help from others, and how to direct their learning, adapt flexibly, and negotiate conflict in a group.

Culture influences collaboration (Care et al., 2018). For example, effective negotiation and conflict-resolution skills draw upon knowledge of social customs and expectations, including expected social interactions. Asian and Western views differ with respect to working and learning related to collaborative interactions (Care et al., 2018; Soland et al., 2013). Some differences are verbal, mediating what is considered appropriate communication and sharing of resources, ideas, or efforts; other differences are non-verbal and mediate what is considered appropriate body language, conflict resolution, and task management tactics. That said, considerably more research is needed on the relationship between culture and collaboration. Cultural differences need to be taken into consideration when assessing the sophistication of collaboration across cultural contexts (Ercikan & Oliveri, 2016).

DEVELOPMENT

How Does Collaboration Develop Over Time?

We know little about how collaboration develops over time (Care et al., 2018; Lai, 2011). Tomasello and Hamann (2012) examined the development of infants' and toddlers' ability to collaborate. By 2 or 3 years of age, children show evidence of collaborative-related abilities, such as forming joint goals and attention. Zhuang and colleagues (2008) found that teamwork and collaboration skills correlate positively with age among adolescents. However, the extant research is insufficient for establishing a broader developmental trajectory of collaboration skills from the early years into adulthood (Lai et al., 2017).

We know little about how collaboration develops over time.

The work of Piaget and Vygotsky throw light on when and how young children may acquire and develop collaboration skills (Lai, 2011). From a Piagetian perspective, for example, children younger than seven may not be able to benefit from collaborative tasks because they lack the ability to take another's perspective. Vygotsky does not identify particular stages at which children may be ready to collaborate. Instead, one would predict from Vygotskian theory that, when the collaborative learning activity occurs within the student's zone of proximal development, student learning should improve.

There are hypothetical learning progressions and performance scales for capturing levels of collaboration. For example, the Essential Skills & Dispositions Developmental Frameworks (Lench et al., 2015) and Deep Learning Progressions (Fullan et al., 2017; Quinn, McEachen, Fullan, Gardner, & Drummy, 2020) provide analytic, multi-dimensional progressions of how students demonstrate less to more sophisticated forms of collaboration. The Essential Skills & Dispositions learning frameworks describe the development of collaboration from childhood to adulthood using four levels for five subskills: self-awareness, communicating, negotiating and decision-making, contributing and supporting, and monitoring and adapting.

The Deep Learning Progressions are K-12 progressions with five levels of student performance. These learning progressions include five subskills: evaluating information and arguments; making connections and identifying patterns; meaningful knowledge construction; experimenting, reflecting, and taking action on ideas in the real world; and using technology for learning (leveraging digital).

The PISA Collaborative Problem-Solving Framework uses four levels for assessing three subskills: establishing and maintaining shared understanding, taking appropriate action to solve a problem, and establishing and maintaining team organization (OECD, 2017). In comparison, ATC21S (2014) uses six levels

for describing collaborative problem solving. This framework is based on 5 strands of social and cognitive skills: participation, perspective taking, social regulation, task regulation, and knowledge building.

Others have focused on one aspect of collaboration. For example, Schellens et al. (2005) described the development of negotiation skills in five phases, from less to more sophisticated. In the less sophisticated phase, students share or compare information; typical cognitive processes are observation, agreement, corroboration, clarification, and definition. In contrast, the most sophisticated form of negotiation is sharing new ideas that the group constructed. Pearson also created a negotiation/conflict resolution scale for its Personal and Social Capabilities Framework, using five levels: non-participant, participator, cooperator, coordinator, and conflict resolver (Lai et al., 2017).

Because of a paucity of relevant research, some success-skills frameworks avoid the term rubric and, instead, use language betraying less certainty regarding grade-level or grade-span proficiency expectations. For example, the Essential Skills & Dispositions "learning frameworks" discussed previously were created to provide educators clear definitions and an understanding of how to recognize skill development. These learning frameworks represent a hypothesized development from beginner to emerging experts, "drawn from research, theory, assessments, and models specific to each skill as well as research on the development of expertise" (Lench et al., 2015, p. iv).

Because of a paucity of relevant research, some success-skills frameworks avoid the term rubric and, instead, use language betraying less certainty regarding grade-level or grade-span proficiency expectations.

In conclusion, the difficulty in describing the development of collaboration is multi-faceted. As Care et al. (2018) argue, (a) research about the developmental nature of 21st century skills, and the interrelations among the subskills and their developmental trajectories, is limited, and (b) there is no research-based sequence of learning 21st century skills—descriptions of how students typically achieve mastery from less to more sophisticated—that yet exists. The extant research typically is observational, producing descriptions of ways students may demonstrate success skills. These descriptions range from less to more sophisticated in hypothesized sequences in development or learning, or learning progressions.

The unknown development of collaboration complicates the teaching and assessing of student success skills, for in order to design learning experiences for students, teachers first must be able to identify the critical behaviors that relate to the learning domain of interest (Care et al., 2018). Teachers must also be able to identify behaviors indicative of different levels of sophistication if they are to teach in a student's zone of proximal development (Care et al., 2018). As Kuhn (2015) argues, educational interventions assume there is a known developmental progression (with the goal of accelerating progress and/or maximizing attainment) and, further, that students will not develop the essential student success skills and dispositions on their own. They need explicit teaching and learning opportunities.

INSTRUCTION

What Are Some Instructional Approaches to Teaching Collaboration?

There is no evidence that simply placing students in a group will, by itself, teach (let alone improve) student collaboration skills (Kuhn, 2015; Lai et al., 2017). Most of us have had the experience of being assigned a group project. The typical approach is to divide up the work into smaller pieces, complete independently and then put the parts together. This type of group work does not require collaboration, and is better described as parallel work.

Most of us have had the experience of being assigned a group project. The typical approach is to divide up the work into smaller pieces, complete independently and then put the parts together. This type of group work does not require collaboration, and is better described as parallel work.

Johnson and Johnson (1994, 2002) posit five factors that mediate the effectiveness of collaborative efforts. These factors are not mutually exclusive:

1. *Positive interdependence*—the group sinks or swims together; no one can succeed unless everyone succeeds.
2. *Individual accountability*—each student is held responsible by group members for contributing one's fair share to the group's success.
3. *Promotive interaction*—each student encourages and facilitates each other's effort to complete tasks and achieve in order to reach the group's goals.
4. *Social skills*—students must be explicitly taught and motivated to use the interpersonal and small group skills necessary for high-quality collaborative activity.
5. *Group processing*—groups periodically reflect on how well they are functioning and, as necessary, adjust work processes to enhance collaboration.

In their review of research on deeper learning, Sergis and Sampson (2019) found there are two primary instructional approaches to cultivate deeper learning: project-based learning and problem-based learning. These instructional approaches arguably promote deeper learning competencies because they are designed to encourage group collaboration, they promote transfer of rigorous learning to new or novel situations, and they are applicable to real-world contexts. Regardless of the instructional approach, however, teachers should attend to important considerations that promote collaborative efforts, such as group formation, teacher's role, task structure/activation, and feedback/reflection (Dillenbourg, 1999; Kuhn, 2015; Webb & Mastergeorge, 2003). Each is discussed in turn below.

Group Formation

The way students are grouped affects the conditions within which effective collaboration may occur (Dillenbourg, 1999). The optimal size for collaborative groups typically is small—fewer than 4 or 5 students (Johnson & Johnson, 2002). Generally, with more students in a group, the easier it is for a student to free ride—letting other students do the work (Salomon & Gloverson, 1989). Small groups encourage promotive interaction, where students facilitate "each other's efforts to achieve, complete tasks, and produce in order to reach the group's goals" (Johnson & Johnson, 1994, p. 3).

Generally, with more students in a group, the easier it is for a student to free ride—letting other students do the work.

Whether students self-select into groups or the teacher makes this determination also can affect collaborative activity and its benefits. This relates to another important consideration: the group's ability mix. Using outcomes on science performance assessments, Webb et al. (1998) found that lower-achieving students benefitted more from heterogeneous grouping, whereas higher-achieving students benefitted more from homogenous grouping. Others have found that prior achievement of group members does not, alone, account for differences in outcomes between groups (Barron, 2003).

Teachers often think about group formation as a way to decrease the negative outcomes associated with collaboration. Salomon and Gloverson (1989) give names to these negative effects, such as the aforementioned free-rider effect. Another is the "sucker" effect, where students who sense they are being taken advantage of by free riders may feel they are being played as a sucker and, consequently, make less of an effort. The teacher's role and task structure are key components in mitigating these negative group outcomes.

Teacher's Role

Teachers play a crucial role in bringing about the desired student collaboration and group outcomes (Mercer, 1996; Rojas-Drummond & Mercer, 2003; Webb et al., 2014). Teachers can engender effective collaboration in various ways. For example, collaboration more likely occurs when teachers set clear guidelines for group participation, such as supporting ideas with reasons or discussing alternative solutions before making any decisions (Webb et al., 2014). Teachers also can establish norms for desired group communication and, further, model those norms (Gillies et al., 2014).

Teachers play a crucial role in bringing about the desired student collaboration and group outcomes.

More productive collaborations occur when students directly engage one another's thinking (Kuhn, 2015). This involves listening, as well as responding to what others in the group say and what is missing from consideration. Collaborations are less successful when students work in parallel—on independent tracks—and ignore or dismiss the contributions of others. Teachers also can provide scaffolding to assist the development of effective collaboration skills through reciprocal teaching strategies and assigning certain roles to students (Schellens et al., 2005). For example, role assignments such as "Elaborator" and "Clarifier" can encourage students to pay attention to, communicate about or elaborate on the thinking expressed by their peers. Other role assignments can encourage students to question the accuracy, completeness, and/or sources of that thinking supports the types of joint activity and learning processes that collaborative activity is intended to engender. In other words, assigned roles cannot be superficial to support effective collaboration; rather, these roles should relate to the ideas and thinking elicited by the task.

Task Structure/Activation

Rote learning and simple tasks are less likely to promote collaboration. The structure of the task must activate particular learning processes and mechanisms in order for effective collaboration to occur (Dillenbourg, 1999). Tasks should be sufficiently complex, authentic, novel, and ill-structured in order to elicit elaborated explanations and group thinking so that all students—not just the highest achieving—can demonstrate the desired performance (Dillenbourg, 1999; Kuhn, 2015; Sears & Reagin, 2013). Tasks lacking a single solution or correct answer are necessary to support the collaborative state by requiring every group member to engage critically with each other's ideas, reasons, and arguments.

Barron (2003) provides a research-based list of learning processes potentially activated by collaborative opportunities: (a) share original insights, (b) resolve differing perspectives through argumentation, (c) explain one's thinking about a phenomenon, (d) provide critiques, (e) observe the strategies of others, and (f) listen to explanations. These learning processes are all interaction-based and jointly activated.

A teacher can listen for variation in the group's conversations to determine if the task is activating these types of talk and, therefore, if the group is functioning as intended. For example, Mercer (1996) created a hierarchy of types of talk, from less to more sophisticated (see Table 3), that researchers have used for evaluating the quality of interactions in groups (Garcia-Mila, Gilabert, Erduran, & Felton, 2013; Rojas-Drummond & Mercer, 2003; van Boxtel et al., 2000). Teachers, too, could use this hierarchy of types of talk in a similar fashion, as well as for modeling and providing feedback to students on more sophisticated forms of collaborative interaction and communication (Ladd et al., 2014).

Table 3.
Types of Talk Activated in Collaborative Learning Activities from Less to More Sophisticated

Disputational Talk	Cumulative Talk	Exploratory Talk
Less Sophisticated		**More Sophisticated**
Group members show disagreement and individualized decision making; few attempts to pool resources or to offer constructive criticism of suggestions.	Group members build positively but uncritically on what each other has said; they use talk to construct a "common knowledge" by accumulation; cumulative talk is characterized by repetitions, confirmations, and elaborations.	Group members engage critically but constructively with each other's ideas; they offer statements and suggestions for joint consideration; these may be challenged and counter-challenged, but challenges are justified and alternative hypotheses are offered; compared with the other two types, knowledge is made more publicly accountable and reasoning is more visible in the talk; progress then emerges from the eventual joint agreement reached.

Teacher Feedback/Student or Group Reflection

As previously noted, the teacher establishes the conditions for effective collaboration, models effective collaboration skills, and creates tasks that activate genuine collaboration (or joint activity). Additionally, the teacher plays a critical role in monitoring the collaborative activity and providing students with formative feedback on the quality of their collaborative effort (Webb & Mastergeorge, 2003). Teachers need to anticipate negative group behaviors, such as free riding, and continuously monitor group interactions for positive interdependence and promotive interaction.

Additionally, the teacher plays a critical role in monitoring the collaborative activity and providing students with formative feedback on the quality of their collaborative effort.

Teachers also should help students be more active agents in their own learning by setting ambitious yet realistic goals for themselves in the collaborative context. Further, teachers can specify times for students to reflect on their own, as well as the group's, actions throughout the course of a project. Such reflections can be critical for improving the collaborative experience.

What Do We Know About the Effects of Instruction on the Development of Collaboration Skills and Student Achievement?

There are three strands of research on collaboration (Lai, 2011): (a) achievement resulting from collaboration versus achievement resulting from a traditional, non-collaborative experiences, (b) identifying conditions associated with more- versus less-effective collaboration, and (c) exploring features of interactions that may contribute to the impact of collaboration on learning, such as the use of virtual and other new technologies.

With respect to the comparison of group and individual performance, collaboration can have important effects on student learning and other student outcomes (Child & Shaw, 2016; Lai & Viering, 2012). For example, students tend to show higher math and science achievement on work completed collaboratively when compared with students working in a non-collaborative context (Rojas-Drummond & Mercer, 2003; Saner, McCaffrey, Stecher, Klein, & Bell, 1994; Webb, 1993). This benefit can have carry-over effects on achievement measures given later (Saner et al., 1994; Webb, 1993). Collaborating can also increase student's academic motivation, interpersonal conflict resolution skills, and academic self-efficacy (Zillmer & Kuhn, 2018).

Collaboration can have important effects on student learning and other student outcomes.

To be sure, not all studies show positive effects of collaborative learning activities; some research, as mentioned above, even find negative outcomes (Barron, 2003; Sampson & Clark, 2008). Kuhn (2015) considered this state of affairs, concluding that the nature of the task and joint activity is of paramount importance for collaborative learning to occur. In other words, it is the substance of student engagement with each other's ideas, and the elaborated explanations, that support student learning in a collaborative context (Webb et al., 2014).

MEASUREMENT/ASSESSMENT

How is Collaboration Typically Measured or Assessed?

There are at least five categories of collaboration assessment types: (a) self- or peer-reports, (b) global rating scales, (c) standardized assessments, (d) observational measures, and (e) performance assessments (Cox, Foster, & Bamat, 2019; Lai & Viering, 2012; NRC, 2011). Table 4 briefly describes these assessment types, along with associated benefits and challenges, and examples from the research literature.

These collaboration assessment types generally range from less to more standardized, and the level of standardization is related to the intended use of the assessment information. For example, less standardized assessment types, such as self- or peer-reports, are intended primarily for formative use in the classroom or for research. In contrast, standardized assessments (e.g., situational judgment tests, computer simulations) are intended mainly for large-scale summative assessment.

What are the Measurement/Assessment Issues Related to Collaboration?

There are instructional, practical, and technical considerations when selecting (or designing) measures of 21st century competencies (Soland et al., 2013). Instructional considerations pertain to the use of assessment information. For example, is the measure intended to be used formatively or summatively? Is it to provide actionable information to teachers, or useful feedback to students? Is the assessment grade, context, or culturally appropriate? Practical considerations relate to cost and ease of administration, delivery, and scoring. And technical considerations center on validity, reliability, and fairness.

The desired inferences that educators wish to make from assessment results will influence what evidence will be collected (NRC, 2011; Wilson et al., 2012). The development of educational and psychological tests typically proceed as follows: define the targeted construct; create tasks to elicit desired responses; select item types; consider the various administration issues; determine the values, codes, or scores to be assigned to student responses; pilot the assessment, using a large and diverse sample of students; model and analyze responses, attending to technical issues such as validity, reliability, and test fairness.

The desired inferences that educators wish to make from assessment results will influence what evidence will be collected.

Table 4.
Collaboration Assessment Types with Brief Description and Some Benefits/Challenges from a Measurement Perspective

Assessment Type	Description	Benefits	Challenges	Examples from the Literature
Self- or peer-reports	Student self- and/or peer-report (survey, questionnaire, assessment, or reflection)	Easy and cost effective to administer; could improve group processes, motivation, and engagement	Response set biases such as social desirability bias; susceptible to coaching and faking	(French et al., 2016; Kelley, Knowles, Han, & Sung, 2019; Lower, Newman, & Anderson-Butcher, 2017; Wang et al., 2009; Wever, Keer, Schellens, & Valcke, 2011)
Global rating scales	Completed by teachers; asked to rate students' collaboration skills	Provide reliable scoring across students by any one teacher	Time consuming; difficult for teachers to observe and rate all students in their class(es); halo effects; lack of consistent interpretation possible across teachers	(French et al., 2016; Wang et al., 2009)
Standardized assessments	Selected and/or constructed response items, situational judgment tests, computer simulations	Use in large-scale educational applications; provide reliable measures for individuals or groups	Tasks may not mirror authentic scenarios; susceptible to social desirability bias, coaching and faking, and confounding variables (e.g., verbal or reading ability)	(Care et al., 2016; Hao et al., 2019; Liu, von Davier, Hao, Kyllonen, & Zapata-Rivera, n.d.; Scoular, Care, & Awwal, 2017; von Davier & Halpin, 2013; Wang et al., 2009)

Table 4.
Collaboration Assessment Types with Brief Description and Some Benefits/Challenges from a Measurement Perspective (continued)

Assessment Type	Description	Benefits	Challenges	Examples from the Literature
Observational measures	Teacher observation of type of talk happening in groups	Based on actual student behaviors (verbal/ nonverbal); related to enacted curriculum	Labor intense; not feasible for large-scale testing;	(Garcia-Mila et al., 2013; Mercer, 1996; Rojas-Drummond & Mercer, 2003; van Boxtel et al., 2000)
Performance assessments	Application of knowledge and skills to a new or novel situation	Authentic and more meaningful and engaging for students	Cost; concerns about reliable scoring and generalizability of student scores (task by occasion by student interactions)	Application of knowledge and skills to a new or novel situation

The development of valid collaboration assessments is based on the meaning and operationalization of the collaborative construct as well as on the intended purpose and use of the assessment information (NRC, 2011). For example, there is a fundamental tension between the nature of group work and the need to assign scores to individual students (NRC, 2011). In most educational settings, teachers want to assess what each student knows and can do relative to either the collaboration process or collaboration outcome—not just what the group can do. But collaboration occurs within a group context, which can obscure contributions from the individual (Lai, 2011). Moreover, if the goal is to assess a student's sophistication in collaboration, is it necessary to observe the student actually collaborating in a group context, or is it sufficient that the student can correctly answer questions about effective collaboration?

Child and Shaw (2016, 2018, 2019) use two approaches to operationalize the collaboration construct for assessment purposes: collaboration as outcome and collaboration as process (as discussed above). Collaboration as outcome focuses on the quality of the product provided by the student or group in order to make inferences about content learning. Collaboration as process, in contrast, focuses on the quality of student interactions. Depending on one's purpose, what would be considered good performance under one approach may be counterproductive under the other. As Webb (1995) concludes, "group processes such as co-construction of ideas, conflict, giving and receiving elaborated help, equality of participation, division of labor, and free riding or social loafing are more or less desirable depending on whether the goal of group assessment is to measure individual student learning or group productivity" (p. 249).

If the goal is to measure collaboration as process, then the assessment should be designed to gather evidence of the quality of student interactions, not the quality or quantity of the group product.

If the goal is to measure collaboration as process, then the assessment should be designed to gather evidence of the

quality of student interactions, not the quality or quantity of the group product (Lai, 2011). On the other hand, if the goal is to measure collaboration as outcome, then the group processes cited above by Webb may actually slow down the group, and the most efficient way to complete a high-quality final product may be to have the students divide up the work, complete the work independently, and rely on high-achieving students to pull the weight of the group. In this way, free riding can actually help groups maximize the quality of the final product, although not considered best practice for improving student learning (Webb, 1995).

What are the Implications of Research for Assessment Design and Use?

Assessment Design

The following implications for assessment design are related to classroom-based assessments in particular. These implications are not limited to collaboration, as they also apply to some of the other student success skills, such as critical thinking.

First, ***assessment tasks should be sufficiently complex and offer sufficient challenge to encourage joint, collaborative activity.*** Overly simplistic, routine, or trivial tasks do not require students to collaborate by negotiating ideas or pooling resources, ideas, and efforts (Lai & Viering, 2012). Obvious and unambiguous tasks provide little fodder for disagreement, group negotiation, elaborated explanations, or group discussion. In other words, simple tasks do not enable group discussion and thinking, nor do they require group members to share the cognitive load (Child & Shaw, 2016).

Similarly, ***assessment tasks should include open-ended and/or ill-structured tasks.*** Open-ended tasks are the opposite of standardized assessments, which rely heavily on forced-choice item types that can assess only limited aspects of collaboration and other 21st century skills (Ku, 2009; Lai & Viering, 2012). Open tasks allow students to decide what information is relevant, how to use the information, and how to demonstrate their understanding of the information; open tasks also allow multiple solution pathways. In contrast, closed tasks typically have one correct solution, and the teacher indicates what information is relevant and how the information is to be presented. An ill-structured task has "no clearly defined parameters, no clear solution strategies, and either more than one correct solution, or multiple ways, of arriving at an acceptable solution" (Lai & Viering, 2012, p. 46). The advantages of ill-structured tasks for the purposes of measuring the collaborative process is that they require knowledge and skills that any one group member is unlikely to possess (Webb et al., 1998). This sets up the conditions for all group members to collaborate.

Assessment tasks should be authentic. As Care et al (2018) state: "the premise for good assessment is that it captures valid indicators of the target construct, . . . [and] to stimulate the behaviors from which these indicators can be captured, the assessment design must mirror the real-life demands of a situation that would provoke those behaviors" (p. 20). Authentic, real-life contexts do not guarantee the validity of the assessment information for any particular use, but authenticity does contribute to validity. Similarly, authenticity is an important consideration for student motivation and engagement—both of which also relate to the validity. Inauthentic assessment tasks are unlikely to stimulate genuine collaborative activity because students are unmotivated or not engaged in the task (as opposed to being incapable of demonstrating collaborative skill).

For assessments of collaboration as process, ***assessment tasks should make student thinking visible and necessary to group success.*** In order to permit formative feedback or the scoring of student's interactions in the group, the assessment task must make student thinking in the group visible (Mercer, 1996;

Teachers can use structured reflections to gather evidence of student thinking and the ways each student contributed ideas to help the group succeed.

van Boxtel et al., 2000). This could be accomplished in several ways. For example, teachers can use structured reflections to gather evidence of student thinking and the ways each student contributed ideas to help the group succeed.

Finally, ***assessment tasks should reflect how context and culture matter.*** Collaborative tasks that work well in one setting, context, or culture may not work equally well in another (Care et al., 2018; Soland et al., 2013). Attending to cross-cultural validity is critical although sparse in the literature (Ercikan & Oliveri, 2016). As Soland et al. (2013) argue, "Extra caution is warranted when considering measures of 21st century competencies, particularly interpersonal and intrapersonal competencies, because these may be more culturally and contextually dependent than traditional academic skills. To the extent possible, the validity of scores on a given measure should always be confirmed locally" (p. 41).

Assessment Use

There are many challenges with assessment use regarding 21st century skills. First and foremost, there is no clear end of grade-level or grade-span standards that defines proficiency for any of the success skills, including collaboration. Empirically validated learning progressions do not yet exist for student success skills. Consequently, it is unclear how students develop competence in the domain of collaboration, and there are no expected levels of collaboration at certain markers in time. It also is unclear what exactly (if anything) becomes more complex over time related to collaboration skills. Is it that collaboration skills, such as conflict resolution, become more sophisticated over time? Or is it that the assessment tasks and disciplinary content to which students are applying collaboration skills become more complex (or novel) over time? Or is it a combination of both?

It is unclear how students develop competence in the domain of collaboration, and there are no expected levels of collaboration at certain markers in time.

An additional challenge with assessment use relates to the creation of rubrics to score and grade student performance in any particular student success skill. Rubrics imply scoring and grading, and grading can have negative effects on student learning (Shepard, 2019). This is because grading can elicit comparisons among students, which can adversely affect student motivation. More, specifically, grading 21st century skills is fraught with potential unintended negative consequences, as the measures are not sufficiently accurate at the individual student level and distort the meaning of grades as indicators of academic achievement. That said, technical concerns are not the primary reason why educators and school systems should avoid grading student success skills.

> " Giving points for effort and collaboration leads to the commodification of these endeavors and invites a performance orientation, for example, working to please the teacher, rather than supporting students to develop a learning or mastery orientation. Factors that enable learning...are more appropriate as targets for formative feedback than for grading." (Shepard, 2019, p. 191)

In this context, grading is especially problematic to the extent that student grades are dependent on accurate self- and peer-reports regarding the quality of the group interactions. One can imagine a student being honest with what they thought they did well and how they could improve in the

In this context, grading is especially problematic to the extent that student grades are dependent on accurate self- and peer-reports regarding the quality of the group interactions.

collaborative context (e.g., contributing resources, ideas, and efforts) if they knew the information would only be used for formative purposes. However, student responses will likely suffer from response-set biases, such as social desirability bias, as soon as they realize their grades are dependent on their own and others' assessments of their collaboration. Additionally, there is a long and deep research base related to assessment for learning and how students learn more from written formative feedback than grades (Black & Wiliam, 1998).

For these reasons, we suggest not using the language of a rubric, but instead creating research-based continua to describe student performance from less to more sophisticated. These continua would be pilot tested on student work in local contexts to evaluate the extent to which they accurately reflect how students across socio-cultural contexts and conditions demonstrate competence in the domain.

Additionally, the continua would provide useful, formative information that teachers could use to guide instruction and provide feedback to students regarding the quality of their interactions in collaborative settings. The pilot testing could determine if the continua provide useful feedback to students, parents, and teachers. Being provided specific behaviors to look for during collaborative activities, and types of talk to attend to, would help teachers know what skills to teach. Further, students could keep these behaviors in mind as they aim to improve their collaborative skills over time. Annotated student work samples from across disciplines and types of assessment tasks would be especially useful in helping teachers to recognize markers for the essential elements of collaboration in student work products and artifacts.

Because the so-called deeper learning competencies (cognitive, interpersonal, and intrapersonal) are intertwined, assessments intended to elicit evidence of a student collaborative skill also will elicit evidence of student's ability to, say, communicate effectively interpersonally and keep themselves on task. The interrelations among student success skills may necessitate a more holistic and complex understanding of student competence within and across content areas. This has implications for the design and use of rubrics in any given student success skill, including collaboration.

The debate over generic versus content-specific collaboration skills is particularly salient in the present context. We recognize there are generic collaborative skills that can be transferred regardless of the discipline or content area. Planning and making decisions, for example, is not dependent on whether we are talking about art or math. That said, we argue that context and content matter for some forms of genuine collaboration to take place. The quality of student interactions is dependent, at least in part, on how well students know the content area. For example, students having expertise in life science are more likely to collaborate effectively because they have ideas and resources to share in comparison with students having little background knowledge. Consequently, teachers should expect variability in student success along some dimensions of collaboration, depending on student knowledge and expertise in the content.

Teachers should expect variability in student success along some dimensions of collaboration, depending on student knowledge and expertise in the content.

CONCLUSION

Collaboration is an oft-cited and important student success skill necessary for work and life in the 21st century. The problem is that the term is conceptually vague and needs a careful construct definition, and greater clarity of its components, for educators to teach students essential collaboration skills and provide them with meaningful and actionable feedback on the development of their collaboration skills over time.

Collaboration can be thought of as either a process or an outcome of joint activity, with the former being typically more in line with how it has been used in the 21st century skills movement (Kuhn, 2015). Collaboration skills are both generic and content/context specific in that the collaborative skills themselves do not typically vary across content areas. However, the content/context in which the collaborative activity is situated can have a significant effect on the ability of students to transfer their skills. Collaboration is also intertwined with other cognitive, interpersonal, and intrapersonal competencies: effective collaboration requires effective communication skills, metacognition, self-direction, project management, and so on.

Teachers play a significant role in setting up the conditions for collaboration to occur. Specifically, teachers should attend to group formation, their role in scaffolding and modeling collaborative skills, task/project structure and design, and feedback to help improve student learning. In general, students benefit cognitively and non-cognitively from genuine collaborative activities, especially those situations requiring elaborated explanations, sharing/critiquing of thinking, and opportunities to bring their funds of knowledge to bear on the complex task or problem.

Assessing 21st century skills such as collaboration are challenging. Educators must attend to the way the assessment task design encourages all students in a group to participate, share thinking, pool resources and ideas, manage the task, regulate the team, and communicate effectively. At potential odds with instructional goals is creating collaboration rubrics to score and grade students. Given the lack of empirical evidence related to how students should develop competence in the domain of collaboration by the ends of certain periods of time (end of grade, end of grade span, end of 12th grade), we recommend that draft collaboration continua be created to describe student performance from less to more sophisticated using shared markers of collaborative processes across the research literature. We recommend the pilot testing of these draft continua against student work to determine the accuracy of their descriptions of student performance and usefulness for teaching and learning purposes in K-12 classrooms.

REFERENCES

American Educational Research Association, American Psychological Association, & National Council on Measurement in Education. (2014). *Standards for educational and psychological testing.* Washington, DC: American Education Research Association and National Academy of Education.

ATC21S. (2014). Assessment and teaching of 21st century skills. Melbourne, Australia: Assessment Research Centre, Melbourne Graduate School of Education, University of Melbourne.

Barron, B. (2003). When Smart Groups Fail. *The Journal of Learning Sciences*, 12(3), 307–359. https://doi.org/10.1207/S15327809JLS1203_1

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first century skills. In P. Griffin (Ed.), *Assessment and Teaching of 21st Century Skills* (pp. 17–66). Springer. https://doi.org/10.1007/978-94-007-2324-5

Black, P., & Wiliam, D. (1998). *Assessment and classroom learning. Assessment in Education: Principles, Policy & Practice,* 5(1), 7–73.

Care, E., Kim, H., Vista, A., & Anderson, K. (2018). Education system alignment for 21st century skills: Focus on assessment. Washington, DC: Brookings Institute.

Care, E., Scoular, C., & Griffin, P. (2016). Assessment of collaborative problem solving in education environments. *Applied Measurement in Education,* 29(4), 250–264.

Child, S. F., & Shaw, S. (2016). Collaboration in the 21st century: Implications for assessment. Cambridge, UK: Cambridge Assessment.

Child, S. F., & Shaw, S. (2018). Towards an operational framework for establishing and assessing collaborative interactions. *Research Papers in Education,* 1–22. https://doi.org/10.1080/02671522.2018.1424928

Child, S. F., & Shaw, S. D. (2019). A purpose-led approach towards the development of competency frameworks. *Journal of Further and Higher Education,* 1–14. https://doi.org/10.1080/0309877X.2019.1669773

Conley, D. T. (2007). Redefining College Readiness. Eugene, OR: Educational Policy Improvement Center.

Cox, J., Foster, B., & Bamat, D. (2019). A review of instruments for measuring social and emotional learning skills among secondary school students (REL 2020-010). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Educaiton Evaluation and Regional Assistance, Regional Educational Laboratory Northeast & Islands. Retrieved from http://ies.ed.gov/ncee/edlabs

Dillenbourg, P. (1999). What do you mean by "collaborative learning?" In P. Dillenbourg (Ed.), *Collaborative learning: Cognitive and computational approaches* (pp. 1–19). Oxford, UK: Elsevier.

Ercikan, K., & Oliveri, M. E. (2016). In Search of Validity Evidence in Support of the Interpretation and Use of Assessments of Complex Constructs: Discussion of Research on Assessing 21st Century Skills. *Applied Measurement in Education,* 29(4), 310–318.

French, B. F., Gotch, C. M., Immekus, J. C., & Beaver, J. L. (2016). An investigation of the psychometric properties of a measure of teamwork among high school students. *Psychological Test and Assessment Modeling,* 58(3), 455–470.

Fullan, M., Quinn, J., & McEachen, J. (2017). *Deep learning: Engage the world change the world.* Thousand Oaks, CA: Corwin.

Garcia-Mila, M., Gilabert, S., Erduran, S., & Felton, M. (2013). The effect of argumentative task goal on the quality of argumentative discourse. *Science Education,* 97(4), 497–523.

Geisinger, K. F. (2016). 21st century skills: What are they and how do we assess them? *Applied Measurement in Education,* 29(4), 245–249. https://doi.org/10.1080/08957347.2016.1209207

Gillies, R. M., Nichols, K., Burgh, G., & Haynes, M. (2014). Primary students ' scientific reasoning and discourse during cooperative inquiry-based science activities. *International Journal of Educational Research,* 63, 127–140. https://doi.org/10.1016/j.ijer.2013.01.001

Greenwald, H. P., & Zukoski, A. P. (2018). Assessing collaboration: Alternative measures and issues for evaluation. *American Journal of Evaluation,* 39(3), 322–335. https://doi.org/10.1177/1098214017743813

Hao, J., Liu, L., Kyllonen, P., Flor, M., & von Davier, A. A. (2019). Psychometric considerations and a general scoring strategy for assessments of collaborative problem solving (ETS RR-19-41). Princeton, NJ: Educational Testing Service.

Hesse, F., Care, E., Buder, J., Sassenberg, K., & Griffin, P. (2015). A framework for teachable collaborative problem solving skills. In P. Griffin & E. Care (Eds.), *Assessment and Teaching of 21st Century Skills* (pp. 37–56). Dordrecht, Netherlands: Springer.

Johnson, D. W., & Johnson, R. T. (2002). Learning together and alone: Overview and meta-analysis. *Asia Pacific Journal of Education*, 22(1), 95–105. https://doi.org/10.1080/0218879020220110

Johnson, R. T., & Johnson, D. W. (1994). An overview of cooperative learning. In J. Thousand, A. Villa, & A. Nevin (Eds.), *Creativity and Collaborative Learning.* Baltimore, MD: Brookes Press.

Kelley, T. R., Knowles, J. G., Han, J., & Sung, E. (2019). Creating a 21st century skills survey instrument for high school students. *American Journal of Educational Research,* 7(8), 583–590. https://doi.org/10.12691/education-7-8-7

Ku, K. Y. L. (2009). Assessing students' critical thinking performance: Urging for measurements using multi-response format. *Thinking Skills and Creativity,* 4(1), 70–76. https://doi.org/10.1016/j.tsc.2009.02.001

Kuhn, D. (2015). Thinking together and alone. *Educational Researcher,* 44(1), 46–53. https://doi.org/10.3102/0013189X15569530

Ladd, G. W., Kochenderfer-Ladd, B., Visconti, K. J., Ettekal, I., Sechler, C. M., & Cortes, K. I. (2014). Grade-school children's social collaborative skills: Links with partner preference and achievement. *American Educational Research Journal,* 51(1), 152–183. https://doi.org/10.3102/0002831213507327

Lai, E. (2011). Collaboration : A Literature Review. Princeton, NJ: Pearson.

Lai, E., DiCerbo, K., & Foltz, P. (2017). Skills for today: What we know about teaching and assessing collaboration. London: Pearson.

Lai, E., & Viering, M. (2012). Assessing 21 st Century Skills: Integrating Research Findings. In *National Council for Measurement in Education.* Vancouver, B.C.

Lench, S., Fukuda, E., & Anderson, R. (2015). Essential skills and dispositions: Developmental frameworks for collaboration, communication, creativity, and self-direction. Lexington, KY: Center for Innovation in Education at the University of Kentucky.

Littleton, K. (2011). Social interaction and learning. In S. Jarvela (Ed.), *Social and emotional aspects of learning* (pp. 149–155). Amsterdam: Elsevier.

Liu, L., von Davier, A. A., Hao, J., Kyllonen, P., & Zapata-Rivera, D. (n.d.). A tough nut to crack: Measuring collaborative problem solving (pp. 344–346). https://doi.org/10.4018/978-1-4666-9441-5.ch013

Lower, L. M., Newman, T. J., & Anderson-Butcher, D. (2017). Validity and reliability of the teamwork scale for youth. *Research on Social Work Practice,* 27(6), 716–725. https://doi.org/10.1177/1049731515589614

McEachen, J., & Kane, M. (2019). *Measuring human return: Understand and assess what really matters for deeper learning.* Thousand Oaks, CA: Corwin.

Mehta, J., & Fine, S. (2019). *In search of deeper learning: The quest to remake the American high school.* Cambridge, MA: Harvard University Press.

Mercer, N. (1996). The quality of talk in children's collaborative activity in the classroom. *Learning and Instruction,* 6(4), 359–377.

National Research Council. (2008). *Research on future skill demands: A workshop summary.* Washington, DC: The National Academies Press. https://doi.org/10.17226/12066

National Research Council. (2011). Assessing 21st century skills: Summary of a Workshop. Washington, DC: The National Academies Press. https://doi.org/10.17226/13215

National Research Council. (2012). *Education for life and work: developing transferable knowledge and skills in the 21st century.* (J. W. Pellegrino & M. L. Hilton, Eds.). Washington, DC: National Academies Press.

OECD. (2013). PISA 2015: Draft collaborative problem solving framework. Retrieved from https://www.oecd.org/pisa/pisaproducts/

OECD. (2017). PISA 2015 collaborative problem-solving framework. Retrieved from https://www.oecd.org/pisa/pisaproducts/

OECD. (2018a). PISA: Preparing our youth for an inclusive and sustainable world: The OECD PISA global competence framework.

OECD. (2018b). The future of education and skills: Education 2030. Retrieved from https://www.oecd.org/education/2030/E2030 Position Paper (05.04.2018).pdf

OECD. (2019). Envisioning the future of education and jobs: Trends, data and drawings. Paris, France: OECD Publishing. Retrieved from https://www.oecd.org/education/Envisioning-the-future-of-education-and-jobs.pdf

Partnership for 21st Century Learning. (2015). P21 framework definitions. Retrieved from http://static.battelleforkids.org/documents/p21/P21_Framework_Definitions_New_Logo_2015_9pgs.pdf

Partnership for 21st Century Learning. (2019). Framework for 21st century learning. Batelle for Kids. Retrieved from http://static.battelleforkids.org/documents/p21/P21_Framework_Brief.pdf

Quinn, J., McEachen, J., Fullan, M., Gardner, M., & Drummy, M. (2020). *Dive into deep learning: Tools for engagement.* Thousand Oaks, CA: Corwin.

Rios, J. A., Ling, G., Pugh, R., Becker, D., & Bacall, A. (2020). Identifying critical 21st-century skills for workplace success: A content analysis of job advertisements. *Educational Researcher,* 49(2), 80–89. https://doi.org/10.3102/0013189X19890600

Rojas-Drummond, S., & Mercer, N. (2003). Scaffolding the development of effective collaboration and learning. *International Journal of Educational Research,* 39, 99–111. https://doi.org/10.1016/S0883-0355(03)00075-2

Roschelle, J., & Teasley, S. D. (1995). The construction of shared knowledge in collaborative problem solving. In C. E. O'Malley (Ed.), *Computer-supported collaborative learning* (pp. 69–97). Berlin: Springer-Verlag.

Rotherham, A. J., & Willingham, D. T. (2010). "21st-century" skills: Not new, but a worthy challenge. *American Educator,* Spring, 17–20.

Salomon, G., & Gloverson, T. (1989). When teams do not function the way they ought to. *International Journal of Educational Research,* 13(1), 89–99. https://doi.org/https://doi.org/10.1016/0883-0355(89)90018-9

Sampson, V., & Clark, D. (2008). The impact of collaboration on the outcomes of scientific argumentation. *Wiley InterScience.* https://doi.org/10.1002/sce.20306

Saner, H., McCaffrey, D., Stecher, B., Klein, S., & Bell, R. (1994). The effects of working in pairs in science performance assessments. *Educational Assessment*, 2(4), 325–338.

Schellens, T., Van Keer, H., & Valcke, M. (2005). The impact of role assignment on knowledge construction in asynchronous discussion groups: A multilevel analysis. *Small Group Research,* 36, 704–745.

Scoular, C., Care, E., & Awwal, N. (2017). An approach to scoring collaboration in online game environments. *The Electronic Journal of E-Learning,* 15(4), 335–342.

Sears, D. A., & Reagin, J. M. (2013). Individual versus collaborative problem solving: Divergent outcomes depending on task complexity. *Intructional Science, 41,* 1153–1172. https://doi.org/10.1007/s11251-013-9271-8

Sergis, S., & Sampson, D. (2019). Unraveling the research on deeper learning : A review of the literature. In *Learning technologies for transforming large-scale teaching, learning, and assessment* (pp. 257–288). Springer Nature Switzerland. https://doi.org/10.1007/978-3-030-15130-0

Shepard, L. A. (2019). Classroom assessment to support teaching and learning. In *The Annals of the American Academy of Political and Social Science* (pp. 183–200). Retrieved from https://doi.org/10.1177%2F0002716219843818

Soland, J., Hamilton, L. S., & Stecher, B. M. (2013). Measuring 21st century competencies: Guidance for educators. RAND Corporation.

Thomson, A. M., Perry, J. L., & Miller, T. K. (2007). Conceptualizing and measuring collaboration. *Journal of Public Administration Research and Theory,* 1–34. https://doi.org/10.1093/jopart/mum036

Tomasello, M., & Hamann, K. (2012). Collaboration in young children. *The Quarterly Journal of Experimental Psychology,* 65(1), 1–12. https://doi.org/10.1080/17470218.2011.608853

van Boxtel, C., van der Linden, J., & Kanselaar, G. (2000). Collaborative learning tasks and the elaboration of conceptual knowledge. *Learning and Instruction,* 10, 311–330.

von Davier, A. A., & Halpin, P. F. (2013). Collaborative problem solving and the assessment of cognitive skills: Psychometric considerations (ETS RR-13-41). Princeton, NJ: Educational Testing Service. Retrieved from https://www.ets.org/Media/Research/pdf/RR-13-41.pdf

Vygotsky, L. S. (1962). *Thought and language.* Cambridge, MA: MIT Press.

Wang, L., Maccann, C., Liu, O. L., & Roberts, R. D. (2009). Assessing teamwork and collaboration in high school students. *Canadian Journal of School Psychology,* 24(2), 108–124.

Webb, N. M. (1993). Collaborative group versus individual assessment in mathematics: Processes and outcomes. *Educational Assessment,* 1(2), 131–152.

Webb, N. M. (1995). Group collaboration in assessment: Multiple objectives, processes, and outcomes. *Educational Evaluation and Policy Analysis,* 17(2), 239–261. Retrieved from https://www.jstor.org/stable/1164563

Webb, N. M., Franke, M. L., Ing, M., Wong, J., Fernandez, C. H., Shin, N., & Turrou, A. C. (2014). Engaging with others' mathematical ideas: Interrelationships among student participation, teachers' instructional practices, and learning. *International Journal of Educational Research,* 63, 79–93. https://doi.org/10.1016/j.ijer.2013.02.001

Webb, N. M., & Mastergeorge, A. (2003). Promoting effective helping behavior in peer-directed groups. *International Journal of Educational Policies,* 39, 73–97. https://doi.org/10.1016/S0883-0355(03)00074-0

Webb, N. M., Nemer, K. M., Chizhik, A. W., & Sugrue, B. (1998). Equity issues in collaborative group assessment: Group composition and performance. *American Educational Research Journal,* 35(4), 607–651. Retrieved from https://www.jstor.org/stable/1164563

Wever, B. De, Keer, H. Van, Schellens, T., & Valcke, M. (2011). Assessing collaboration in a wiki : The reliability of university students ' peer assessment. *The Internet and Higher Education,* 14(4), 201–206. https://doi.org/10.1016/j.iheduc.2011.07.003

Wilson, M., Bejar, I., Scalise, K., Templin, J., Wiliam, D., & Irribarra, D. T. (2012). Perspectives on methodological issues. In P. Griffin (Ed.), *Assessment and Teaching of 21st Century Skills.* Springer. https://doi.org/10.1007/978-94-007-2324-5

Zhuang, X., MacCann, C., Wang, L., Liu, L., & Roberts, R. D. (2008). Development and validity evidence supporting a teamwork and collaboration assessment for high school students (ETS RR-08-50). Prince: Educational Testing Service.

Zillmer, N., & Kuhn, D. (2018). Do similar-ability peers regulate one another in a collaborative discourse activity? *Cognitive Development,* 45, 68–76. https://doi.org/10.1016/j.cogdev.2017.12.002

APPENDIX A

Selected Operational Definitions of Collaboration from the Literature and Related Frameworks

Table A.1 below uses color coding to highlight that there are several collaboration skills that are consistently repeated across sources. These collaboration skills include: planning and making group decisions; communicating about thinking with the group; contributing resources, ideas and efforts and supporting group members; and monitoring, reflecting, and adapting individual and group processes to benefit he group. Some of the skills are only partially represented in the operational definitions, and some overlap more in different sources. The language used in the operational definition may or may not be exactly the same as the collaboration skills and there are other ways the operational definitions could be coded and organized. This is just one approach—it is not exhaustive or mutually exclusive.

1. Plan and make group decisions: decide with the group how best to manage and complete the task or project; work with the group to assign roles or tasks; use negotiation or conflict-resolution skills as necessary to plan and make group decisions.
2. Communicate about thinking with the group: seek clarity about others' thinking; respectfully express how thinking makes sense or is lacking in some way; solicit alternative perspectives and input from all group members; elaborate on the explanations of others.
3. Contribute resources, ideas, and efforts and support group members: contribute ideas, efforts and resources; support group members as needed; own task assignments and work quality; provide feedback on the work of others.
4. Monitor, reflect, and adapt individual and group processes to benefit the group: reflect on individual and group progress and processes; work with team to adjust group efforts to meet goal; adapt individual and/or group processes to benefit the group; check in with group members about progress.

Table A.1.
Operational Definitions of Collaboration from the Literature and Related Frameworks

Source	Operational definition	Related Frameworks
(ATC21S, 2014)	Collaborative problem solving involves an individual's collaborative processing that engages both cognitive and social skills. Social skills • Participation • Perspective taking • Social regulation Cognitive skills • Task regulation • Knowledge building	ATC21S

Table A.1.
Operational Definitions of Collaboration from the Literature and Related Frameworks (continued)

Source	Operational definition	Related Frameworks
(Binkley et al., 2012)	Collaboration and teamwork are ways of working comprised of knowledge, skills, attitudes/values/ethics with four subskills. • Interact effectively with others • Work effectively in diverse teams • Manage projects • Guide and lead others; be responsible to others	ATC21S
(Care et al., 2018)	Primary dimensions of collaboration include: • Social interdependence • Interpersonal skills • Task-related processes Specifically, collaboration includes knowledge, skills and attitudes such as: • Interacting effectively with others and having meaningful conversations; • Knowing when it is appropriate to listen or to speak (social regulation); • Working effectively in diverse teams (e.g., conflict resolution and team management) • Introducing new ideas and sharing of resources; • Exercising flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal; • Assuming shared responsibility for team work; • Perspective taking; and • Valuing the individual contributions made by each team member	ATC21S
(Child & Shaw, 2016, 2018)	Collaboration *as process*—focus on quality of student interactions 'State' maintenance • social interdependence • communication • cooperation/division of labor Socio-cognitive • sharing resources • introduction of new ideas • conflict resolution Collaboration *as outcome*—focus on quality of student or group output/product Cognitive change/learning • achieved via collaborative process • 'before' and 'after' of student knowledge/understanding Product • The final 'artifact' or solution to set problem	Cambridge Assessment

Table A.1.
Operational Definitions of Collaboration from the Literature and Related Frameworks (continued)

Source	Operational definition	Related Frameworks
(Lai, 2011; Lai et al., 2017)	• Interpersonal communication • Negotiation or conflict resolution • Task management/team regulation	Pearson P21
(Lench et al., 2015)	Collaboration has five components—the first and the last highlight the interconnectedness of collaboration with self-regulation and metacognition as "components that guide an individual's contributions to group dynamics and outcomes" (p. 4). • *Self-awareness* • Communicating • Negotiating & decision-making • Contributing & supporting • *Monitoring & adapting*	Essential Skills & Dispositions
(OECD, 2017)[1]	Collaborative problem solving involves an individual's cognitive processing that engages both cognitive and social skills. • Establishing and maintaining shared understanding • Taking appropriate action to solve a problem • Establishing and maintaining team organization	PISA Collaborative Problem Solving
(Partnership for 21st Century Learning, 2015)	• Demonstrate ability to work effectively and respectfully with diverse teams • Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal • Assume shared responsibility for collaborative work, and value the individual contributions made by each team member	P21 EdLeader21
(Zhuang et al., 2008)	• Task-related process skills (collaborative problem solving, decision making, planning and task coordination, strategy formulation, coordination, goal setting, performance management) • Cooperation with others (adaptability, interpersonal skills) • Influencing team members through support and encouragement (confidence building, social support) • Resolution of conflicts or disagreements among team members via negotiation strategies (conflict solving, communication) • Guidance and mentorship of other team members (leadership, helping others)	ETS Collaborative Problem Solving

[1] This resource contains a more exhaustive listing of existing frameworks and models for collaboration skills. See pages 38-41.

MEASURING STUDENT SUCCESS SKILLS: A REVIEW OF THE LITERATURE ON COLLABORATION

Center for Assessment

National Center for the Improvement
of Educational Assessment
Dover, New Hampshire

www.nciea.org