Collaborative problem-solving education for the twenty-first-century workforce

The complex research, policy and industrial challenges of the twenty-first century require collaborative problem solving. Assessments suggest that, globally, many graduates lack necessary competencies. There is a pressing need, therefore, to improve and expand teaching of collaborative problem solving in our education systems.

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In industry, academia and government, there is an increasing emphasis on collaborative problems that require deep knowledge to solve difficult challenges. The assumption is that collaboration is essential because some tasks are too complex for a person to work through alone. This trend is accelerating with increasing need to solve complex environmental, social and public health problems. To this end, there is a concomitant need to develop pedagogical approaches that incorporate collaboration into academic curricula and better prepare the workforce for learning collaborative problem solving (CPS) strategies[1,2].

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A global shortfall in CPS

For the first time ever, an international assessment of CPS took place in 2015, and was reported recently by the Organization for Economic Cooperation and Development (OECD). Students from 52 countries were tested on CPS in the widely recognized Programme for International Student Assessment (PISA). The report documents significant deficiencies when it comes to student collaboration competencies[3]. Less than 10% of students across OECD member countries scored at the highest level. At this level, students can complete complicated problems by monitoring group behaviour in service of each other's collaborative roles (for example, overcome obstacles and resolve conflict). Even on the lowest complexity test items, less than 30% of students demonstrated success. This extremely low success rate is troubling because these are precisely the skills needed in the workforce. Given that these students had learning opportunities in and out of school over many years, it is clear there is a global deficit in acquiring collaboration competencies.

The PISA report dramatically points out this deficit; however, speculations about this problem have been circulating for years. Previous studies document the lack of a sufficient workforce capable of collaborating in the modern knowledge economy[4]. Previous reports also describe the lack of a science, technology, engineering and mathematics workforce capable of teamwork across disciplines[5]. Still others point to the importance of group work, and instructor assessment of group performance, to improve learning and teamwork in science[6].

Moreover, studies on workforce preparation identify gaps between the knowledge, skills and abilities (KSAs) that employers are seeking and those held by college graduates[7]. These prominently include teamwork and interpersonal skills, such as communication across professions[4]. A survey by the American Management Association found that higher-level managers believed that college graduates do not have the skills needed for collaboration[8]. They cite an overemphasis on 'task knowledge', or course content focusing on high-tech skills such as mathematics and science, without parallel emphasis on communication and collaboration. More problematic, though, is that college graduates' self-perceptions of KSAs diverge from employer assessment[7]. For example, nearly two-thirds of college graduates believe they can effectively work in a team, whereas only approximately one-third of managers believe college graduates demonstrated this competency.

What's missing from curricula?

The PISA report points to the need for increased focus on developing collaboration competencies for all students. These competencies include establishing and maintaining a shared understanding (for example, who knows what about the problem), taking action to address needs for the team to solve the problem (for example, identifying subtasks) and keeping the team organized (for example, defining roles and ensuring members are contributing)[3]. To accomplish this, we must improve students' learning of collaboration across disciplines and professions, over and above their mastery of content knowledge.

We argue that these deficiencies arise from a set of interrelated factors that, unless addressed in education, will continue to

produce graduates who collaborate poorly. The first question is why do students vastly overestimate their collaboration skills? We suggest that student misperceptions arise from a dangerous combination of a lack of systematic instruction coupled with inadequate feedback. On the one hand, students engage in a great deal of group work in school, with most courses requiring some kind of collaborative project. On the other hand, students rarely receive meaningful instruction, modelling and feedback on collaboration. Decades of research on learning shows that explicit instruction and feedback are foundational to domain mastery. Classes that implement CPS do provide some instruction and task-relevant feedback, but it is unlikely that they have incisive instruction and feedback on teamwork. Consequently, students graduate with a misperception of what they have learned about teamwork. They conflate learning course content material in any group context with collaboration competency.

Overall, there is a stark mismatch between the importance CPS carries for real life and instruction of CPS in existing K–20 (educational system from kindergarten to undergraduate and graduate degrees) curricula. Workforce leaders, policymakers and teachers expect educational systems to foster development of collaboration competencies, but there is little to no explicit CPS curriculum. The recent inclusion of CPS into PISA 2015 reveals the need to gather benchmark evidence of students' collaboration competencies at relative and absolute levels. Contrary to what is typically found with assessment across a set of competencies, in PISA 2015, performance in mathematics, reading and science correlated much lower with CPS[3]. This result suggests that CPS does not entirely 'come along' with the content curriculum and that it is common to teach content without teaching collaboration.

Improving CPS education

Given the above facts and findings, we make the following recommendations to address the global need to improve CPS. Drawing from disciplines that study cognition, collaboration and learning[4,5], our recommendations are meant to improve research and education with a focus on instruction, opportunities to practice and assessment. Across these is the need to attend to the core features of teamwork as identified in the broad research literature on groups and teams.

First and foremost, researchers should collaborate with educators to make more systematic use of instructional strategies devised to teach components of collaboration. Research on groups and teams has produced methods that focus on team processes relevant to complex forms of work. For example, knowledge building training[5] emphasizes communicative processes that make explicit the structure of member knowledge (for example, mental models), as well as assumptions and interpretations members have about their knowledge. External representations make such knowledge explicit and concrete and build shared understanding. Also relevant is training that draws attention to the team process following interactions. Team reflexivity training[5] requires that members reflect on previous performance episodes by focusing on met or unmet objectives, strategies used to address task needs and efficiency of collaborative interactions. Not only would research on such interventions help, but also more generally they would enable study of how students come to learn team processes that improve future interactions.

Second, in addition to systematic implementation of instruction on team process, students need opportunities for practice. Collaboration in the classroom is common in science and engineering[9], and education level and nature of the content will dictate the team and task context. For example, in introductory science classes, students may collaborate while learning about fundamental physics concepts, how they should be integrated and how they can be applied for particular problems. At these levels, knowledge is usually distributed unevenly across students such that they need to communicate what each knows as well as their interpretation of what needs to be applied. Teams need to discuss member contributions and evaluate their appropriateness while also using logical analyses to identify and evaluate solutions. In these stages of learning, basic interpersonal competencies associated with relationship management (for example, encourage participation) and communication (for example, listening to learn) are needed. At more advanced levels, students address problems that require not only richer domain knowledge but also connections to more complicated scenarios. For example, upper-level students might collaborate on complex socio-environmental problems such as overfishing wherein stakeholder factors necessitate consideration of species population dynamics and local economies. At these levels, collaboration requires sophisticated forms of perspective taking to consider alternative views of problem elements. Considering the need to provide more structured practice opportunities, problem-based learning is a method tested in a variety of settings with meta-analytic support documenting effectiveness[5]. Teams work on real-world problems like those described above, first discussing any lack of understanding and identifying gaps in knowledge. From this, they form explicit learning goals and collaborate to gather and integrate knowledge necessary to produce a solution. Research must thoroughly examine these in the classroom to understand how they can best provide the contextual grounding that fosters integration of collaboration skills[9].

Finally, there is a need for more consistent assessments that measure teamwork to provide diagnostic feedback on collaboration. To achieve this, there should be a more systematic integration of methods on team training with the educational programmes devised for learning to work in teams[1–3]. This includes consideration of self-ratings of soft skills as well as peer-ratings that assess categories of team involvement such as contribution to the team's work and keeping the team on track. Also needed are assessments of interpersonal competencies such as conflict resolution (for example, reactions to conflict) and assertive communication (for example, addressing differences without intimidation)[5]. Critical to this assessment is ensuring students receive feedback regularly, can compare it to self-assessments and have opportunities to calibrate it in future collaborations. Research must explore how to incentivize CPS skills and integrate grades on collaboration into overall student assessment.

Conclusions

What is needed is cooperation between researchers and educators to study the systematic implementation of instruction, practice and feedback focused on team processes, with attention to the collaboration competencies that drive effective team outcomes[1,2]. Closer cooperation between educational and team researchers will enable contributions to both fields. Education researchers can provide insights into fundamental learning processes lacking in team research (for example, developmental trajectory for learning CPS). Furthermore, educational research can add contextual factors (for example, socio-environmental differences) and/or situational features (for example, classroom settings), as well as student characteristics (for example, academic self-concept) leading to improvements in team training theory. As these will probably interact with our recommendations, collaborations integrating concepts and methods can also inform both fields. This includes a better understanding

of generalizability, exploring what theories or methods need adapting, and studying what forms of assessment are appropriate to different settings (for example, group project portfolios versus traditional survey or performance outcomes).

Our recommendations have developed enough of an evidence base to warrant study in classroom collaborative activities and in K–20 curricula[1,5]. In combination, they provide a powerful methodology for studying how students can better learn teamwork competencies. This can have long-term economic benefits. Research shows that those who have balanced strengths (for example, in social and mathematics skills) have higher salaries than those who excel in only one area[10]. If these recommendations are achieved, the global educational system will better prepare a workforce capable of addressing the kinds of complex scientific and societal problems that our planet will face in the coming decades. ❐

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Competing interests

The authors declare no competing interests.