Proposing an Alternative Framework for the Assessment of Collaborative Problem Solving

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Abstract: We propose a framework for the assessment of collaborative problem solving, by letting children solve knowledge-rich problems both individually and collaboratively, and assessing differences between two modes. Results show that they improved performances, indicating their potential. We also identified two obstacles for releasing the potential: self-consciousness of gaps in ability with the partners and the lower sense of goals. Assessment frameworks are discussed to examine children’s differences at the edge of their capability.

Keywords: collaborative problem solving, assessment, 21st century skills, collaborative learning

Introduction
The knowledge society requires defining and assessing 21st century skills in ways integral to the processes of teaching of higher quality. Scardamalia et al. (2012) summarized that ways of integrating 21st century skills into curricula can range from superficial to fundamental levels: “additive change” (addition of new skill objectives and new curriculum content), “assimilative change” (existing curricula and teaching methods are modified to place greater emphasis on critical thinking, problem solving, collaboration, etc.),” and “systemic change” (schools are transformed into knowledge-creating organizations).” Although we should cause systemic changes in every school, the OECD’s Collaborative Problem Solving (CPS) framework (OECD, 2013) adopted in PISA2015 can invite schools to resort to additive changes, because it aims at assessing “domain-general” capabilities (Looi & Dillenbourg, 2013) and captures no emergent properties of collaboration such as creating new questions. Instead, we should at least make assimilative changes happen by proposing an alternative framework. Our proposal is simple: letting children solve domain-specific, knowledge-rich problems both individually and collaboratively, and assessing differences between two modes to examine their CPS by addressing questions below (Figure 1).

Methods
We report results of 49 pupils (6th graders) from three public schools. We made 23 pairs and one trio on the principle of “pairing randomly” to reveal their potential regardless of their partners’ performance, character etc.

We used problems from the National Assessment of Academic Ability which Japanese ministry of education has carried out in mathematics and language for 6th and 9th graders. There are two types of problems: Type A “knowledge” problem and Type B “use” one, roughly corresponding to TIMSS and PISA literacy problems respectively. The first main problem (i.e., part) concerns the parallelogram and has three sub-problems, the last of which asks its areas in an information-overloaded situation. The second main problem questions the decimal fraction and percent of basis: for example, the second sub-problem asks “Distance between outstretched thumb and forefinger is called ‘Ata.’ Chopsticks that fit one’s hand are ‘one Ata and a half’ long. Ata is roughly equal to 10% of one’s height. If your sister is 140cm tall, how long will her chopsticks be?” The third main problem concerns about the ratio, asking pupils if they can pick up numbers from a cross table to compare ratios.

Figure 1. Assessment framework for CPS
We assigned one main problem from the three above to each pupil, asking her or him to solve it individually in eight minutes, then to solve it with a nearest partner in eight minutes, and finally to separate them again and explain how she or he had solved it to the experimenter (we did this only in difficult problems). We gave a set of worksheets to each pupil in the individual solving phase, withdrew it, and gave another set to each pair in the paired solving phase to let members of the pair discuss over the worksheets.

**Results and discussion**

Table 1 shows the ratios of individuals (in the individual solving and explaining phases) or pairs (in the paired solving phase) who answered correctly with justification. The table also includes average scores of the problems in the National Assessment. Their performances in the paired phase went up from those in the individual phase, especially up to 100% in three problems. Those performances mostly stayed in the individual explanation phase. We examined what kinds of pairing yielded what kinds of results by collapsing the data to find that 1) 100% of six pairs (one trio is included) both members of which solved the problems correctly in the individual phases solved them again correctly, 2) 90% of ten pairs one member of which solved the problems solved correctly, and 3) 50% of eight pairs neither member of which had solved them individually solved the problem correctly. The results up to here indicate children’s potential of their collaborative problem solving.

There were however pairs who did not reach correct solutions and individuals who did not “internalize” solutions. The process analyses indicate that unsuccessful pairs did not take many turns nor discuss reasons and justifications, being satisfied when they got any answers. Especially when one member hesitated to ask questions to her or his partner, their conversations did not come alive and their solutions were not “taken away.” In contrast, successful pairs tackled the problem on an equal basis without hesitation regardless of the correctness of their solutions, explored and discussed many possibilities, wrote detailed answers including expressions and their meanings, and gave newer questions.

Thus, we can identify two obstacles: 1) pupils’ excessive self-consciousness of gaps in the math grade or ability with their partners, and 2) their lower sense of “goals” (for example, reaching solution means “getting things done”). They are typical features resulting from the instruction of “backward approach” (Scardamalia et al., 2012), in which the goal is set by a teacher and specified as a collection of utterances and behaviors. Students compete with each other to reach the goal first, which yields unnatural ranks among them and prevents further explorations beyond the goal. But for these obstacles, pupils could engage in “healthy” collaborations.

We cannot tell if the differences between successful and unsuccessful were caused by certain factors (e.g., skills, experiences, climates of schools) or only by chance (e.g. relationship between partners). More studies are needed, but we see some prospects of our framework. First, it reveals children’s basic understandings in the domain as well as how they deepen them through collaboration, because our assessment is knowledge-based. Second, if we can accumulate positive results, we will be able to show skills of collaboration not as something to add but as something to pull out from children. Third, if this assessment is coupled with education for idea improvement and proves its merits, it gives teachers hints for both assimilative and systemic changes.

<table>
<thead>
<tr>
<th></th>
<th>Parallelogram(3) (n=28)</th>
<th>Ata(1) (n=13)</th>
<th>Ata(2) (n=13)</th>
<th>Ratio (n=8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Average</td>
<td>18%</td>
<td>46%</td>
<td>33%</td>
<td>24%</td>
</tr>
<tr>
<td>Solo</td>
<td>36%</td>
<td>77%</td>
<td>77%</td>
<td>50%</td>
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<tr>
<td>Pair</td>
<td>75%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Solo (Again)</td>
<td>—</td>
<td>—</td>
<td>85%</td>
<td>88%</td>
</tr>
</tbody>
</table>

**References**


**Acknowledgments**

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