

Assessing collaborative problem solving

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Objectives:

1. To examine a generic performance assessment framework
2. To use the specifications of collaborative problem solving for assessment
3. To discuss the forms of evidence needed in assessing collaborative problem solving
4. To explore the use of development progressions as an assessment strategy

We need first of all to recap what we mean by collaborative problem solving and what is involved in designing collaborative problem projects or tasks.

We discussed last time the stem involved in designing a collaborative problem based task or project:

1. Define the problem or collaborative project.
2. Identify project elements and components in detail;
3. For each component identify the resources that are essential. These can be;
 - a. materials
 - b. equipment
 - c. strategies
 - d. knowledge
 - e. experience

Of course it is not possible to allocate knowledge, experience, or perhaps even strategies. So when teaching collaborative problem-solving these varying amounts of knowledge, experience and known strategies may affect the way in which the group as a whole functions. They might also affect how individuals interact. In assessment of the collaborative problem-solving skills of both individuals and the team it is essential to attempt to control the influence of these three inputs. However materials and equipment can be allocated differentially to each member of the group.

4. Allocate to each participant non-overlapping, unique sets of resources necessary to be contributed to the project completion or problem resolution. Divide the resources amongst the participants with no shared or common resources.
5. Clearly state the goals of the task or problem solution and observed to students procedure in the task.
6. Explain to the participants that they must identify the problem, sort out a strategy to resolve the problem or complete the task
7. The students also need to develop a means of keeping records of their decisions and discussions. For face-to-face attempts at collaborative problem-solving or collaborative project work keeping records is an essential aspect of the assessment process.

Assessing CPS

In ATC21S a blueprint was developed for the definition of component skills of collaborative problem. It identified the kind of evidence that would be sought in assessing those skills. We now examine each of these broad areas of skill in detail and identify the sub skills and evidence that we would be seeking when monitoring students working together in a collaborative problem-solving context.

Collaborative problem solving and reasoning

Inductive reasoning focuses on exploring the available information and finding patterns. This is particularly important in collaborative tasks where communications about goals of sub-tasks is essential, and in this case would focus on exploration of information and identifying connections between elements of the problem space. Deductive reasoning focuses on understanding the implication of logic statements and rules which can have applications in solving problems in the real or virtual worlds. Collaborative problem solving tasks challenge the participants to locate information, identify patterns (as part of the inductive process), and then establish rules for content and procedure, test ideas and check solutions (as part of the deductive process).

Some of the early work on problem solving was conducted in the 1970s by Polya. According to his theory, problem solving is a sequence of processes such as understanding the problem, devising a plan, carrying out the plan, looking back and checking. The OECD PISA problem solving framework (OECD, 2003) closely followed the Polya process and specifies four processes -(Recognising and Understanding, Formulating, Selecting a Strategy and Solving, Reflecting and Communicating). These approaches are similar to the ATC21S hypothetico deductive approach (Griffin, 2014) where the development of understanding engages a search for information and patterns as the inductive component, and the strategy and solution are based in rule identification and hypothesis testing as the deductive steps.

The role of collaboration in collaborative problem solving

There is a reasonable consensus around the world about the nature of collaborative problem-solving, but a further issue needs to be resolved. There is general agreement that collaborative problem-solving is an important skill. But in an educational setting such as in a science class, or history class, the role that collaborative problem-solving can and would play is still in question. For example, do we measure collaborative problem-solving as a process that transfers from science to history to mathematics and to other subjects? Is it a stand-alone skill? If it is a stand-alone skill, can we teach this to students and what would be the kind of curriculum and teaching strategy that might be used to instruct students in collaborative problem solving for itself. Collaborative problem solving however may be a facilitating factor that enables the student's to collaborate through problems that enable them to learn higher-order skills in science, mathematics, history or even physical education. In other words is collaborative problem-solving a target non-cognitive skill of its own or is it a facilitating skill to enable other domain specific discipline, cognitive based skills to be acquired. If it is targeted as a non-cognitive skill in its own right we must presume that the capability ` can be taught.

CPS as a target skill:

If collaborative problem-solving is curriculum independent then it must be based on the development of skills other than the cognitive skills embedded within the school content curriculum defined as science, mathematics and so on. Even if it is curriculum independent it would be still domain specific in its own right and, as such, would need a definite strategy for direct instruction. Moreover it would need to identify someone in the school or university context whose responsibility it was to devise the teaching intervention and to take responsibility for the effects of direct instruction. In the ATC21S project it was presumed that the social aspects of problem solving provided a targeted, non-cognitive, hierarchical process. It was argued to be a hypothetico deductive process that involved inductive reasoning and deductive reasoning just as would be expected in scientific thinking. It was also assumed that these skills can be taught directly.

Collaborative problem solving requires partnerships to be formed and agreements to be reached on the nature of ideas or hypotheses to be tested and the way the team will proceed. Then the collaborating students need to make observations and to seek information. In ATC21S two students were separately provided with different stimulus sources of information. They were required to act according to general prompts for the technology based configuration developed by Griffin and Care (2015): *“What do you have? What do you see? What kind of pictures do you have on the screen? What kind of instructions do you have and how can we communicate these? What kinds of information do you think you or I need?”* Through facilities such as real-time chat, collaborating students ascertained each other's information and sources in order to make decisions about procedures that would help solve the problem. However, this does not necessarily contribute to the individual's capacity to generalise the collaborative problem-solving skill as a targeted learning outcome.

CPS as an enabling skill: Curriculum embedded collaborative problem solving tasks are those that draw on particular skills and knowledge derived directly from school curriculum. These tasks involve the development of assessable curriculum-based problems that can be solved collaboratively and connect with everyday teaching and learning in the subjects such as physical education or history for example. In these CPS tasks the role of collaboration will be secondary to the students' understanding and skill development in the subject discipline. Collaboration will involve the provision of a facilitating role in the measurement of student cognitive skills in the subject discipline.

Described scales (Development Progressions)

One of the critical components of both teaching and assessing these complex skills is the availability of what are known as described (derived) scales also known as developmental progressions. These provide a way of describing levels of increasing expertise in collaborative problem solving. They allow, and perhaps even require, the teacher to be an observer as part of their role of a formative assessor. When the teachers act as observers they need to focus on, and document their observations of students' activities and demonstrations of specific skills. In this way the teacher can informally assess a student's development and identify the appropriate intervention for scaffolding the skills that are described in the dimensions of collaborative problem-solving.

Normally we standardise the assessment in terms of the instrument and the administrative procedures that must be followed precisely. In ATC21S we allowed observations and the method of observation to be variable across teachers or contexts. Using a developmental progression means that the report standardised and the assessment method or observations and data, are variable. Using derived scales means that the process of assessment and reporting is reversed. While this may seem odd in the first instance, it is not such a radical departure from education measurement theory. We assume that the derived scale is a relatively fixed description of the competency development. Under those circumstances it should be a matter of indifference which assessment strategies used to gather evidence and to map the student's performance on to the derived scale. In physical measurement for example the height of the table is independent of which ruler we use to measure the height. It's also independent of the unit length or height that we use measure the table. The height of the table is to change some intervention must take place. We can add to the table legs, or we can cut some out. This is the equivalent in teaching and learning. Measures of student development should be independent of the measuring process, and the reason for change in the students' ability measure would be an intervention that enables students grow socially cognitive. So the report is standardised process and the assessment method is allowed to be free flowing. The teacher, acting as an observer, becomes the most important assessment instrument. So even in the absence of a formal and standardised measuring instruments the derived scales for collaborative problem solving provide a useful framework for the teachers to interpret their observations of student behaviour when their operating within a collaborative environment.

Empirically derived scales are constructed from assessment data and describe the development of skills and knowledge of large numbers of people. Statistical methods are used to determine the typical or expected order of acquisition of skills, knowledge, and attitudes. Examples of empirical progressions include those used in the OECD's PISA and the TIMSS international studies. Empirical progressions represent a typical learning pathway for students, and can therefore be a useful frame of reference for teachers. They don't define the specific learning pathway of each individual student but they do help to define a typical pathway teachers can use for planning assessment and instructional purposes. The important thing is that they help the teachers to become disciplined and informed observers of what students are doing, saying, making or writing. Teachers then have a base for inferring the students' levels of proficiency or competence.

The examples that we present have been used with students as young as 11 years old in elementary school and we have seen postdoctoral candidates struggling to resolve the complexity of problem solving in a collaborative context. This does not mean that the tasks, the skills or the students' locations on the scales are independent of age. A great deal of research still needs to be done to determine how age and experience affect the capacity to demonstrate collaborative problem-solving skills.

Derived scales have many uses. Teachers can use them for more than just monitoring the development of student skills in collaborative problem solving. Once they know the point of intervention that teachers can develop intervention strategies to assist the student growth. In addition, teachers can use the information provided by the described scales to 'look ahead' on a developmental continuum to decide what sorts of goals and objectives to set for their students, the types of experiences or materials they need to provide, and how to challenge their students with interesting and achievable projects.

Collaborative problem-solving – dimensions and elements

We now we will explore each of the social and cognitive dimensions in some detail and identify the kinds of skills and behaviours that we would need to observe to enable us to conclude that students are demonstrating a specific level of competence.

Social components of collaborative problem-solving

It seems obvious to say that successful collaborative problem-solving relies on the social skills of participants. It is, perhaps, of more assistance to identify the types of social skills that are brought into play when two or more people collaborate to solve a problem. For the purpose of assessment, these could be described using a rubric of social skill **capabilities** such as *participation*, *perspective-taking*, and *social regulation*. Within each capability we can define a series of elements and the evidence or **indicative behaviour** that would be needed in order to conclude that the student was exhibiting the capability. Finally, we explore the indicative behaviour and differentiate between students on the basis of how well they exhibit that behaviour in terms of a series of quality criteria. Griffin and Robertson (2014) defined rubrics as the combination of performance indicator and a series of quality criteria. It is

not necessary to have the same number of quality criteria for every indicator and Humphrey's work (2014) shows that by varying the number and range of quality criteria within a rubric the validity of the measure can be enhanced. This is clearly demonstrated in application of rubrics to the assessment of students with learning difficulties (Woods and Griffin, 2013).

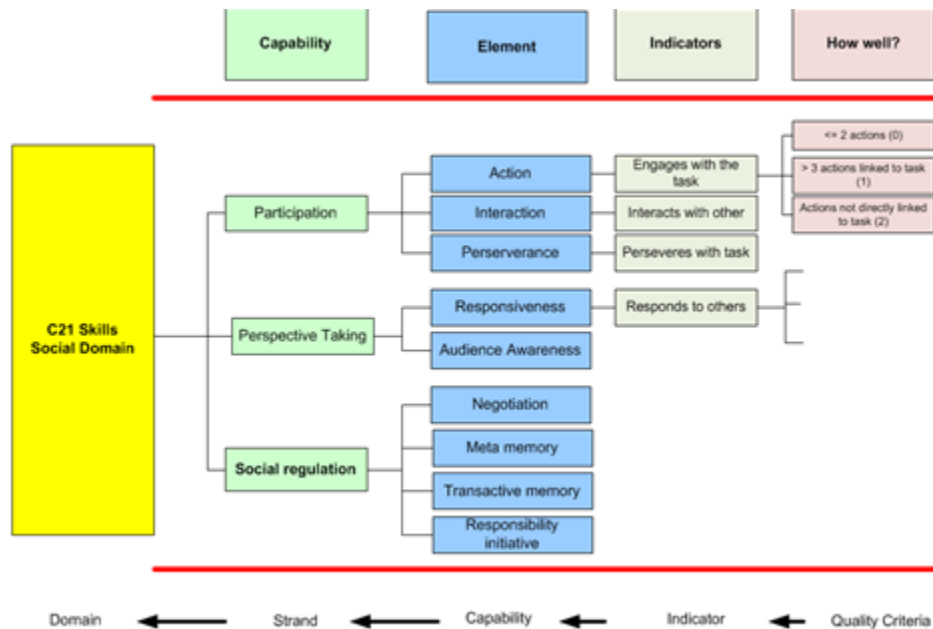


Figure 1: Measurement structure for social skill assessment

The ATC21S project has demonstrated how computer activity log files can be used to identify the kinds of actions and activities that students take while collaboratively solving problems. These activities and actions can then be interpreted in terms of the elements of social and cognitive skills in collaborative problem solving. Examples of the elements and indicative behaviour within a social domain identified within activity log files are shown in the following table.

Element	Behavioural Indicator
Participation	
Action	Activity within environment
Interaction	Interacting with, prompting and responding to contributions' of others
Task completion/perseverance	Undertaking and completing a task or part of a task individually
Perspective-taking	
Adaptive responsiveness	Ignoring, accepting or adapting contributions of others
Audience awareness (mutual modelling)	Awareness of how to adapt behaviour to increase suitability for others
Social Regulation	
Negotiation	Achieving a resolution or reaching compromise
Self-evaluation (metamemory)	Recognising own strengths and weaknesses
Transactive memory	Recognising the strengths and weaknesses of others
Responsibility initiative	Assuming responsibility for ensuring parts of the task are completed by the group

Figure 2: Indicative behaviours or elements of social domain in collaborative problem solving.

Participation skills

What sorts of skills do we expect to observe when we hear that someone is a good participator? It can be helpful to distinguish between three sub-skills of participation - action, interaction, and task completion.

- **Action** – this is defined as the general level of participation of an individual, irrespective of whether this action is coordinated with the efforts of others. Problem solvers differ in the level of competence with which they act in a group. While some may be passive, others become active when provided with sufficient prompts and supports, and yet others will demonstrate an ability to act independently and from their own initiative.
- **Interaction** - this refers to the capacity to respond to or coordinate with others, ranging from answering an inquiry, to actively initiating and coordinating efforts, or prompting others to respond.
- **Task completion skills** - refer to the motivational aspects of participation, including a sense of responsibility for the outcomes of collaborative effort. This can also be described as **persistence** or perseverance or, in some cases, **grit**.

Perspective-taking skills

Perspective-taking encompasses the ability to see a state of affairs from the viewpoint of another person; to apply contextual knowledge to interpret information provided by others, and to adapt one's statements or actions with sensitivity to the needs and presumed understanding of listeners/observers. Within an assessment framework of collaborative problem-solving, this can be viewed as two sub-elements – **responding** skills or responsiveness and **audience awareness**. Then we define and search for indicative behaviours that illustrate the presence or absence and the relative quality of each of those elements.

- **Responsiveness** – refers to a capacity to integrate contributions of

collaborators into one's own thoughts and actions.

- **Audience awareness skills** - refer to the ability to tailor one's contributions to the presumed or expressed needs of others, or to make actions visible and comprehensible to collaborators.

Social regulation skills

One potential benefit of collaboration is the diversity of knowledge and experience that group members bring to a problem-solving challenge. However, diversity best supports collaborative effort when participants know how to cope with different viewpoints and opinions or, in other words, where they have strong social regulation skills or elements. We can distinguish between **four** sub- elements related to social regulation:

- **Metamemory** indicative behaviours describe the capacity to evaluate one's own knowledge, strengths, and weaknesses. It is a reflective capacity that focuses on how the person operated and how they learned the skill they have demonstrated.
- **Transactive memory** indicative behaviours describe a person's understanding of the knowledge, strengths and weaknesses of collaborative partners. This is also a reflective process where the person considers the behaviour and performances of their partner in terms of how successful or valuable their partner's activity contributed to the solution.
- **Negotiation skills** become evident where differences between the partners are being resolved. In such an instance, successful collaborators need to find ways to reconcile different perspectives and opinions and/or accommodate differences.
- **Responsibility** initiative takes into account that problem solvers may differ in the way they take initiative within a collaborative context. Some focus mainly on their individual tasks, while others work on a shared problem representation, a strategic plan is offered to lead the group towards a solution, and regular monitoring of the group's progress. It is possible to regard responsibility initiative skills as evidence of leadership.

Cognitive domain of collaborative problem-solving

The cognitive skills that are important for successful collaborative problem-solving are similar to those needed for individual problem-solving. They refer to the ways in which problem solvers manage a task at hand and the reasoning skills employed. To further explore the nature of this domain, we can identify capabilities that include elements such as **task regulation** and **knowledge building**. The overall structure of the measurement framework for cognitive domain skills is similar to that presented earlier for the social domain. The expectations of people demonstrating competence within the cognitive domain are the **task regulation** and **knowledge building** skills. The elements of each of these illustrate the specific capabilities that need to be demonstrated. Six elements of task regulation were identified by Hesse et al. Three elements of knowledge building were identified. Indicative behaviours for each of these elements then form the basis of the rubric.

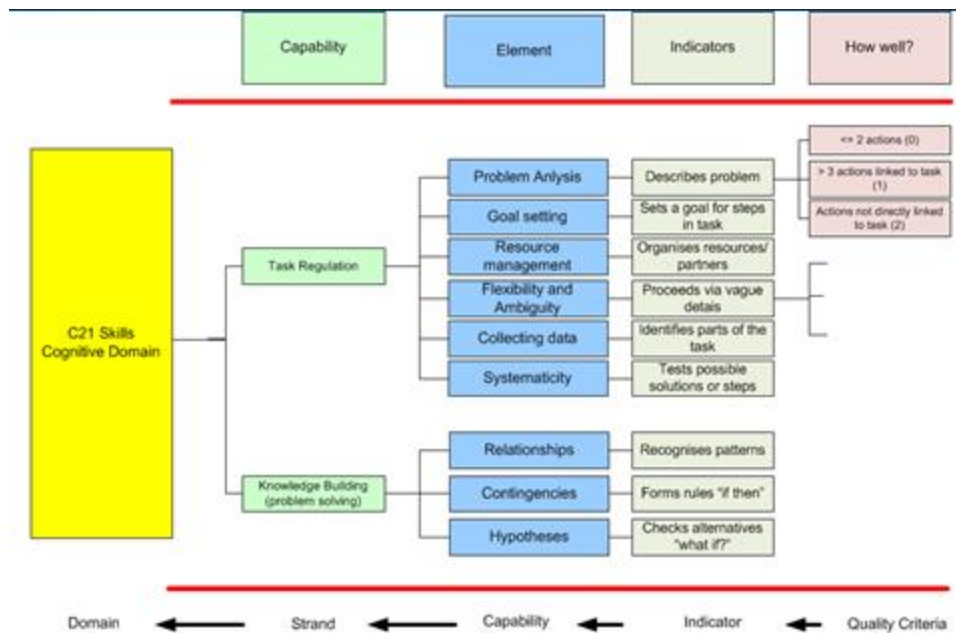


Figure 3: Measurement Structure for Cognitive Domain Assessment Rubrics

Task Regulation Skills

Most collaborative problem-solving tasks can only be accomplished if available resources are identified and information elements about them are collated and shared. Therefore, an important flexibility and ambiguity aspect of planning is collation of data and the management of resources that are available to oneself and to one's collaborators. To assess planning skills within the context of collaborative problem-solving it is useful to distinguish six sub-skills – problem analysis, goal setting, resource management, and planning complexity:

1. **Problem analysis** - refers to the ability to identify the elements of a task and the information available for each of the component parts. This also entails recognition of the interdependences that might arise between components of the problem space. It requires a student to be able to identify the need for pertinent pieces of information; to understand the relationships between them and patterns that might emerge; it further requires an understanding of how pieces of information are interdependent.
2. **Goal-setting** - refers to the formulation and sharing of specific sub-goals that will help to monitor the process of collaboration progress towards problem resolution. The collaborative problem solving group needs to formulate specific goals. These goals and take the form of rules *“if I do A then B should occur and I will be able to make progress towards goal C.”*
3. **Resource management** - reflects the ability to plan how collaborators can bring their resources, their knowledge, or their expertise to the problem-solving process and how they make decisions about the

process of conflating data.

5. **Flexibility skills** - Many collaborative problems can be somewhat ambiguous. Tolerance for ambiguity is a characteristic that can help overcome the barriers in problem-solving activities. Moreover, collaborative problem solvers need to be adept at changing plans in a flexible manner. We can think about the flexibility required for successful collaborative problem-solving as a range of sub-skills including tolerance for ambiguity, breadth of focus, and communication. Flexibility also involves the capacity to negotiate and to understand the perspective of other collaborative partners. Different levels of ambiguity tolerance lead to different collaborative problem-solving behaviours – some collaborators only become active in unambiguous situations, some react to ambiguity by further exploring the problem space, whereas some collaborators are likely to interpret ambiguous situations in a way that helps them in joint decision-making about the next solution step. Where there is an imbalance in these skills and capacities, the progress towards resolving issues associated with ambiguity may be more difficult. The symmetric nature of the collaborative teams may need to be taken into account in resolving differences in collaborative problem-solving skill.

- As to breadth, a low skill level is displayed if collaborative problem solvers follow only a single line of inquiry.
- A medium level entails trying multiple approaches being discussed and explored amongst the collaborators once an impasse is reached, or once new evidence is available via monitoring.
- A high level of breadth leads to a re-organization of problem representation by the group, or planning activities being identified by the collaborators once progress through the problem space is impeded.

5. **Collecting data** – In a collaborative problem-solving context, the actions of one partner may have a consequence for another and these need to be monitored and recorded. It is a design feature that, in a collaborative context, each of the partners lacks specific and crucial information, or alternatively each participant controls specific resources, information or has particular expertise unique. Also, in realizing that the each person lacks crucial information, there is a need to develop strategies to acquire this information, the collaborators are developing important monitoring activities. In collaborative problem-solving, this type of monitoring becomes essential, as different problem solvers typically have access to different types of information, or have different means to access needed information. The way in which the collaborators link this information and record cause and effect enables them to establish rules of operation which they can share in order to make progress towards the problem solution. These skills refer to the ability to detect when and how missing information can be acquired and shared.

- Some collaborative problem solvers lack skills to recognize a need for information and may lack the skill of either providing or acquiring information from collaborative partners.
- At a medium skill level, information needs are recognized, but only with regard to the current activity or problem state.
- A high level of information acquisition skills entails adequately assessing the need for information with regard to current, alternative, and future problem space or states.

6. Systematicity - refers to the thoroughness and efficiency of the problem-solver's approach.

- The most basic level of systematicity involves a trial and error process.
- Using forward search through a problem space bears witness to a medium level of systematicity,
- Whereas high systematicity can be inferred if forward and backward search are combined through means-ends analysis or similar techniques, and followed by reflective monitoring activities.

Knowledge Building Skills

The learning skills demonstrated by collaborative problem solvers involve many of the steps already explained in the cognitive and social aspects of collaborative problem-solving. Through their progress in a collaborative problem-solving task, individuals can learn about a content domain, learn strategies and how to deal with setbacks, or learn how to coordinate, collaborate, and negotiate with others. In another approach to solving complex problems a possible hierarchy for cognitive development related to problem-solving, an approach that can help us envisage ordered categories of response to problem-solving challenges:

1. Relationships within the data

Recognising relationships and patterns in the data is important when the collaborators are attempting to build an information base to define the problem space collaboratively and to identify links between actions and consequences, between observations and patterns, and to identify gaps in the knowledge required to make progress.

In the first category (beyond random guessing or individual trial and error), the students typically relied on identifying isolated elements of information. Trial and error is essentially an individual approach, and is indicative of a very low level of collaborative problem-solving skills.

In a collaborative setting, in which resources and information are unevenly distributed, these elements need to be shared.

Problem solvers at this skill level generally describe connections between elements of information (data) and form patterns of observations, which can be shared between collaborators.

2. Contingencies

At the this level of knowledge building, systematic observations of cause and effect enable players to formulate and discuss the potential of rules, either for the regulation of the task or the manner of collaboration. At a more sophisticated level, rules (If....then) are used to complete steps or parts of the problem solution. It entails planning that takes multiple pathways to a solution into account. Collaborators also need to discuss and evaluate the suggestions for progress toward the problem solution and consequences of each action or decision.

3. Hypotheses

At times this may mean that the partners need to propose generalisations about events within the problem-solving solution strategy and to be able to formulate and test hypotheses. This may be as simple as the collaborating partners proposing to one another with such suggestions as “what about we try this” or “whether that happens or not seems to depend upon ex-happening”. This equates to conjecture or hypothesis testing on the part of the partners collaborating in the problem-solving space. Hesse et al have defined these capabilities using three sub headings or elements. Griffin, (2014) described them as a hierarchy of problem solving.

For the more elaborate sub-tasks, more able students demonstrate an ability to generalise to a range of situations by setting and testing hypotheses, using a “what if...?” approach.

Overview of cognitive domain

So the cognitive domain collaborative problem-solving is a complex, coordinated cognitive activity among two or more people. It is evident that efficient problem-solving does not rely on any single or uniform skill, but rather a set of distinguishable sub-skills or capabilities, some of which are deployed in accordance with situational needs. The evidence of these capabilities being deployed can be accumulated in a number of ways. And it is beneficial to identify how well each of these capabilities and indicative behaviours are being demonstrated.

This is presented in Table 1, with some examples of relevant cognitive capabilities and elements shown on the left of the table and behaviours that could be observed among students with low, medium, or high level skills extending across the table. This provides the teacher with a basic rubric that might be used for assessing the collaborative behaviour. However it is difficult to observe directly people interacting in a collaborative context. Methods of observing and recording might make use of the derived scales.

Cognitive skill	Low level	Medium level	High level
Task regulation skills			
Resource management	Uses own resources	Allocates own resources to partner	Decides on use of joint resources to complete task
Collects information	Recognises the need for more information	Searches for and interrogates information	Organises information
Systematicity	Random trial and error	Strategic sequence of actions	Systematically exhausts possible solutions
Flexibility and ambiguity	Inaction in ambiguous situations	Explores ambiguous situations	Uses ambiguity to inform decision making
Problem analysis	Takes problem at face value	Divides problem into subtasks	Identifies necessary sequence of subtasks
Sets goals	Sets general goal such as task completion	Sets goals for subtasks	Sets goals that recognise relationships between subtasks
Knowledge building skills			
Relationships	Focuses on isolated pieces of information	Links pieces of information	Identifies patterns among multiple pieces of information
Cause and effect	Activity is undertaken with little or no understanding of consequence of action	Identifies sequences of cause and effect	Plans strategy based on a generalised understanding of cause and effect
Reflects on and monitors hypotheses	Tests hypothesis	Modifies hypothesis	Reconstructs and reorganizes understanding of the problem

Table 1: A framework of cognitive skills for collaborative problem-solving

Developmental Progressions for Collaborative Problem Solving

The ATC21S project initially identified more than 400 indicators or items of information which enables us to interpret derived scales of five dimensions when the capabilities are treated as separate dimensions (participation, perspective taking, social regulation, task regulation and knowledge building), two dimensions when the domains are treated as separate dimensions (social, or cognitive) or one general dimension of collaborative problem solved. The two-dimensional model provides described scales with six levels of development in each of social and cognitive development. The five dimensional model separates the cognitive domain into the capabilities task regulation and knowledge building and the social domain into the capabilities of participation skills, perspective taking skills and social regulation skills. Each of the levels within the derived scales describes the kinds of behaviours that teachers might watch for and note in their students. This framework provides teachers with an opportunity to identify the student's Vygotsky zone of proximal development for instructional intervention. Teachers will vary in the way in which they use direct observation skills in the classroom in order to monitor and promote growth in the various domains and capabilities of collaborative problem-solving amongst the students. Teachers need to work together in their own collaborative groups in order to find the best way forward in this process. In the meantime research is need to explore this process and provide sound practical advice to teachers.

Collaborative Problem Solving - One dimension
Assumes joint responsibility, synthesises and incorporates feedback, evaluates performance of self and others, tailors communication, resolves differences.
Participates in tasks irrespective of familiarity or scaffolding, initiates and promotes interactions, responds to perspectives of others, comments on performance of others, asks for feedback on own performance, attempts to resolve differences
Shares resources and information, modifies communication for mutual understanding; acknowledges performances of others, comments on own performance.
Interacts to solve the problem; discusses task with others; contributes to understanding of others; reports own activities.
Works with others when the task is familiar or scaffolded; communicates with others about significant events and/or resources.
Works independently; acknowledges communication from others.

The second model presented here examines both the social and cognitive dimensions separately.

Two dimensions - social and cognitive dimensions

	SOCIAL	COGNITIVE
Level 6	At this level, the student works collaboratively through the problem solving process and assumes group responsibility for the success of the task. Feedback from their partner is incorporated and used to identify solution paths or modify incorrect ones. The student can evaluate their own and their partners performance and understanding of the task. The student may tailor their communication and manage conflicts with partner successfully, resolving differences before proceeding on a possible solution path.	The student's sequential investigations and systematic behaviour require fewer attempts for success and are completed in an optimal amount of time. The student works with their partner to identify and use only relevant and useful resources. The student has a good understanding of the problem and can reconstruct and/or reorganise the problem in an attempt to find alternative solution paths.
Level 5	At this level, the student is able to actively participate in scaffolded and unscaffolded environments. The student initiates and promotes interaction with their partner and acknowledges and responds to contributions from their partner. Despite efforts, differences in understanding may not be fully resolved. The student is able to comment on their partner's performance during the task and asks their partner about their progress in the task.	At this level the student's actions appear to be well thought out, planned and purposeful, identifying the necessary sequence of subtasks. The student identifies cause and effect, basing their goals on prior knowledge and uses suitable strategies to gain a correct path solution for both simple and complex tasks. The student can modify and adapt their original hypotheses, in light of new information, testing alternatives hypotheses and adapt additional or alternative of thinking.
Level 4	At this level, the student perseveres to solve the task as shown by repeated attempts and/or multiple strategies. They share resources and information with their partner and modify communication where necessary to improve mutual and common understanding. Students have an awareness of their partner's performance on the task and can comment on their own performance.	At this level the student can identify connections and patterns between multiple pieces of information. The student is able to simplify the problem, narrow their goal focus and increase co-working by planning strategies with their partner. The student adopts strategic sequential trials and increasing systematic exploration. The student can successfully complete subtasks and simpler tasks.
Level 3	At this level, the student shows attempts to work towards solving the problem. They become aware of their partner's role in the collaborative problem solving process and recognise the need to engage with their partner. They discuss the task with their partner and make contributions to their partners understanding. The student reports to their partner regarding their own activities on the task.	At this level the student recognises the need for more information, realising that they may not have all the required resources and allocates their own resources to their partner. They attempt to gather as much as possible and begins connecting pieces of information together.

Level 2	The student actively participates in the task when it is scaffolded but works largely independently. Communication between partners occurs more frequently but is limited to significant events and sending resources necessary for the task.	At this level, the student identifies possible cause and effect of actions, demonstrates an initial understanding of the task concept and begins testing hypotheses and rules. The student limits their analysis of the problem, using only resources and information they have. The student also remains limited in their goal setting generating broad goals.
Level 1	At this level, the student commences the task independently with limited interaction from partner, mainly prompted by instructions. They may acknowledge communication cues by their partner but have not started to work collaboratively. Most communication occurs at the beginning of tasks and only in those tasks where the instructions are clear.	At this level, the student explores the problem space but this is limited to following instructions, adopting a singular approach, and focusing on isolated pieces of information. Trial and error appears random and there is little evidence of understanding the consequences of actions resulting in a lack of progress through the task.

The most complex of the descriptions incorporates cognitive and social dimensions divided into their sub-dimensions. Cognitive dimension is broken down into task regulation and knowledge building. The social dimension is broken down into participation skills, perspective taking skills, and social regulation skills. It is noticeable that the abilities of students to determine the composition of these scales. We have no indicators of participation at the top level of the distribution. Accordingly we appear to have identified at the fifth level a ceiling of participation skills. Similarly with the social regulation skills there appears to be no data or no behaviours that we were able to identify to define a lower level skill in these particular progressions. What this means hearers that perspective taking and social regulation demand a higher level of ability in collaborative problem solving before evidence of these skills can be observed. It also means that for participation skills there appears to be a limit of participation allowable within the tasks that were developed in the ATC 21 this project.

Nevertheless these progressions provide a framework for teachers to use in interpreting their observations of student behaviour. Put simply it means that the teacher needs to use a highlighter pen to illustrate the progress that each individual student is making. This is an informal approach to assessment based upon a standard report and freestyle assessment strategies.

5 Dimensions combining strands within social and cognitive

	5 DIMENSIONS				
	COGNITIVE		SOCIAL		
LEVELS	TASK REGULATION	KNOWLEDGE BUILDING	PARTICIPATION	PERSPECTIVE TAKING	SOCIAL REGULATION
Level 6	The student's approach to the task is systematic. They continue to engage in	The student has a good understanding of the problem and		The student can tailor communication with their partner based on their awareness of their	The student assumes group responsibility for the success of the task. They can manage

	<p>sequential investigations and systematic behaviour in subsequent task pages that have increased in difficulty. Their actions require few attempts and are hence completed in an optimal amount of time. They have developed an awareness of which resources are most useful and works with their partner to identify the relevant resources and disregard those that posed no benefit in previous trials.</p>	<p>can reconstruct and/or reorganise the problem in an attempt to find a new solution path.</p>		<p>partner's understanding, and are easily understood from the start of the task.</p> <p>The student incorporates the contributions from their partner to suggest new solution paths or modify incorrect ones. They use solutions provided by their partner and work more collaboratively through the problem solving process.</p>	<p>conflicts with partner successfully, resolving differences before proceeding on a possible solution path. The student is able to evaluate their overall performance in the task. They are also able to evaluate the strengths and/or weaknesses of their partner based on their performance during task.</p>
Level 5	<p>The student can identify the necessary sequence of subtasks in order to achieve task completion. Actions appear to be well thought out and planned and each action appears purposeful. The student plans goals based on knowledge and experience from previous goal outcomes and subtask completion. They note information which may be useful in future tasks /subtasks or for an alternative solution path.</p>	<p>The student can identify cause and effect and use suitable strategies to gain a correct path solution for both simple and complex tasks.</p> <p>The student can modify and adapt their original hypotheses, in light of new information, testing alternatives hypotheses and altering their course of thinking.</p>	<p>The student is able to actively participate in scaffolded environments. The student initiates and promotes interaction with their partner often before entering their own answer.</p>	<p>The student acknowledges and responds to contributions from their partner but does not make changes to their original course of action.</p>	<p>The student attempts to resolve differences in understanding with their partner but resolution of differences are not reached. The student is able to comment on their partner's performance during the task and asks their partner about their progress in the task.</p>
Level 4	<p>The student adopts strategic sequential trials and increasing systematic exploration. They narrow their goal setting and focus on successfully complete a subtask before moving on. The student simplifies the problem, analysing it in stages and plans strategies with their partner.</p>	<p>The student can identify connections and patterns between multiple pieces of information. The student can successfully complete subtasks and simpler tasks.</p>	<p>The student perseveres to solve the task as shown by repeated attempts and/or multiple strategies.</p>	<p>The student modifies communication with their partner to improve mutual understanding and share resources and information.</p>	<p>The student comments on or share information to their partner regarding their own performance while attempting the task. They can reach a common understanding with their partner in regards to the task. The student is aware of their partner's performance on the task.</p>
Level 3	<p>The student becomes aware of the need for more information pertaining to the task and begins to gather as much information as possible. The student realises that they may not have all the required resources and allocate their own resources to their partner.</p>	<p>The student begins to connect pieces of information together.</p>	<p>The student shows attempts to work towards solving the problem. The student discusses the task with their partner by responding to communication cues and requests.</p>	<p>The student makes contributions to their partners understanding.</p>	<p>The student reports to their partner regarding their own activities on the task.</p>

Level 2	The student limits their analysis of the problem by only using the resources and information they have and, following system instructions. They make good use of their own resources. The student will remain limited in their goal setting with broad goals such as completing the task.	The student tests their hypotheses based on the information they have. They identify possible cause and effect of actions and repeats attempts in order to gain more information about an actions outcome.	The student actively participates in the task when it is scaffolded. Communication between partners occurs primarily when something significant happens in the task. The student is aware of their partner's role and sends resources when they are necessary for task progression.	The student is not overtly responsive to their partner, often taking a long time to respond or not at all and tends to ignore their partners contributions.	The student still works largely independently taking responsibility for their own actions during the task. The student is aware of their own level of performance during the task.
Level 1	The student explores the problem space by clicking on various resources often in a random fashion. However, if the student has difficulty understanding the task they make very little attempt to explore the problem space. They engage in singular approaches to trial and error in an attempt to build knowledge of the problem space. They attempt to solve the problem through an apparent unsystematic guessing approach and tend to repeat errors or reproduce unproductive actions with no clear indication of advancing through the task within several attempts.	The student continually attempts the task with the same approach with little evidence of understanding the consequences of actions taken. The student focuses on each piece of information individually; only following the specific instructions provided.	The student commences the task independently and task exploration is mainly directed by system instructions. The student shows limited interaction with partner. They may acknowledge communication cues by their partner but have not started to work collaboratively (i.e. sharing information or resources). Most communication occurs at the beginning of tasks and only in those tasks where the instructions are clear.		

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