acara AUSTRALIAN CURRICULUM, ASSESSMENT AND REPORTING AUTHORITY

Collaborative problem-solving online assessment and the Australian Curriculum

Interim project report

August 2016

NSW GOVERNMENT Education Public Schools

Australian CURRICULUM

Contents

EXECUTIVE SUMMARY

The Collaborative Problem-solving Online Assessment and the Australian Curriculum project aimed to develop innovative high-quality assessment that elicits valid, reliable data on students' collaborative problem-solving skills. The Australian Curriculum, Assessment and Reporting Authority (ACARA) and the New South Wales Department Department of Education (NSW DoE) have worked in partnership with Janison (a learning and assessment platform provider) to develop new forms of assessment for general capabilities. The partnership has recognised that this is a shared challenge, and a better solution will be achieved through collaboration.

The report outlines the development of the draft Australian Curriculum Assessment Framework for Collaborative Problem-solving (ACCPSAF) based on the Australian Curriculum general capabilities of Critical and Creative Thinking, and Personal and Social Capability.

The project has achieved a high level of success in sharing knowledge and expertise in online assessment of collaborative problem-solving skills, particularly with educational partners, the Swedish Association of Local Authorities and Regions (SALAR), the National Council for Curriculum and Assessment (NCAA) Ireland, and the technical partner Janison.

A major component of the project has been the development of prototype online tasks to assess collaborative problem-solving using an online management system that allows automatic collection of data while students interact with a randomly selected partner via a chat box. The tasks are dynamic and interactive in nature and are presented through a rich real-world context via a virtual scenario.

The writing and online production of the tasks together with the creation of the ACCPSAF and the marking/scoring rubrics for each task have enriched the understanding of how collaborative problem-solving may be addressed in online assessments.

A unique aspect of the project was the simultaneous capture of students' actions and text responses while they were interacting with a partner, sometimes located in different schools and communities. The ability to capture students' thinking and communication with others, along with indicators of their level of knowledge and skills, has the power to transform models of assessment.

There is general agreement within the project team and partners that the project has provided unique opportunities to explore alternative modes of assessment. The analysis of the extensive and complex data collected at the trial in October 2015 will provide insight into the validity and reliability of the data on student performance and the validity of the assessment framework. The analysis will allow an evaluation of the criteria and the levels in the marking rubric. It will also inform the evaluation of the automated scoring process in relation to the student actions and their chat, to test collaborative problem-solving skill development and the competency of Australian students.

The provision of effective online assessments of collaborative problem-solving is a shared global challenge. It is clear from this project that there is great potential for further research and development in this evolving space.

OVERVIEW

Purpose of the report

This report provides a synthesis of information arising from the Collaborative Problem-solving Online Assessment and the Australian Curriculum project (March 2014 – June 2016).

The report:

- describes the project and its background in relation to the Australian Curriculum
- discusses the project achievement in relation to the project aims
- describes processes involved in developing innovative assessment tasks of collaborative problem-solving skills
- provides a summary of quantitative and qualitative data from task trialing
- provides findings from cognitive interviews
- articulates possible future directions.

Introduction

There is wide recognition nationally and internationally that 21st century skills, including collaborative problem-solving skills, are essential for our students.

> There has been a shift in advanced economies in the skills that are sought and valued by graduates of our schools, and by the workplaces and broader communities in which these young people will participate. This means that the curricula taught in schools must broaden in scope to include domains of learning to prepare students for 21st-century citizenship and employment. (OECD, 2013)

The Melbourne Declaration on Educational Goals for Young Australians (2008) identified essential skills for 21st century learners – in literacy, numeracy, information and communication technology (ICT), thinking, creativity, teamwork and communication.

The Melbourne Declaration underpins the development of the Australian Curriculum. The seven general capabilities encompass the knowledge, skills, behaviours and dispositions that, together with content in the eight learning areas and the three cross-curriculum priorities, will assist Australian students to live and work successfully in the 21st century.

> The new Australian Curriculum pays serious attention to what are referred to as 21st century skills but does not use that nomenclature because the skills are not unique to the 21st century. (McGaw, 2013)

The Australian Curriculum general capabilities are identified as:

- Literacy
- Numeracy
- Information and Communication Technology Capability
- Critical and Creative Thinking

- Personal and Social Capability
- Intercultural Understanding
- Ethical Understanding (ACARA, 2013).

In recognition that 21st century skills are important components of the curriculum, which require new modes of assessment and that this is shared problem that would benefit from networked global exploration, ACARA and NSW DoE joined the Collaborative Assessment Alliance (CAA).

Background to the project

The Collaborative Assessment Alliance (CAA) was a global partnership, created and administered by Collaborative Impact, to design and share online collaborative problem-solving assessment tasks. Collaborative Impact is a social innovation organisation established to develop and manage highly effective cross-sector and multi-stakeholder partnerships that address major social and developmental challenges.

In accordance with ACARA's work plans for 2014-15 and 2015-16, endorsed by ministers in October 2014 and May 2015 respectively, ACARA contributed to this international collaborative assessment initiative.

ACARA and NSW DoE joined the alliance in recognition that 21st century skills are important components of the curriculum that require new modes of assessment. Other CAA partners included the Swedish Association of Local Authorities and Regions (SALAR), the National Council for Curriculum and Assessment (NCAA) Ireland and the technical partner, Janison.

As a result of initial investigations by the joint team from ACARA and NSW DoE, two parts emerged for the Australian project. The first part was the development of four interactive online tasks to assess collaborative problem-solving, as described in the CAA agreement.

To complement the CAA work, ACARA, with support from NSW DoE, added a second part to the project involving the development of an Australian Curriculum Collaborative Problem-solving Assessment Framework (ACCPSAF) that is aligned to the Australian Curriculum general capabilities of Critical and Creative Thinking, and Personal and Social Capability.

To develop a valid and reliable framework, a practical method needed to be developed to implement four interactive online collaborative problem-solving tasks to assess student performance and report individual achievement. The intention was that the data would provide evidence to support the ACCPSAF as a model. It would also contribute to deeper understanding of how collaborative problem-solving may be addressed in online assessments. It may be that in the longer term valid and reliable online assessments can be developed for use by schools to validate school-based assessments of students' collaborative problem-solving.

Assessment of collaborative problem-solving

Two projects of particular significance to the Collaborative Problem-solving Online Assessment and the Australian Curriculum project are:

- Assessment and Teaching of 21st Century Skills project (ATC21S)
- PISA 2015 Collaborative Problem-solving (CPS) assessment.

Assessment and Teaching of 21st Century Skills project (ATC21S)

As a result of the ATC21S™ project, empirical progressions for collaborative problem-solving (CPS) were developed and published. These provide descriptions of skills at different levels of development. The ATC21S cognitive skills are refined to two basic elements: task regulation and knowledge building. Social skills are described through the elements of participation, perspective taking and social regulation.

> The concern of ATC21S was not only with the definition and identification of 21st century skills (Binkley et al., 2012), but with the methods appropriate for assessment of these (Wilson, Bejar, Scalise, Templin, Wiliam, & Torres-Irribara, 2012), the types of technologies on which these might depend (Csapó, Ainley, Bennett, Latour, & Law, 2012), the teaching approaches that might be deployed (Scardamalia, Bransford, Kozma, & Quellmalz, 2012), and the implications of these for policy change (Darling-Hammond, 2012). From the broad-ranging and comprehensive review of these issues, ATC21S then turned to demonstrating the implications of these theoretical perspectives through its focus on collaborative problem-solving (Griffin & Care, 2014).

PISA 2015 Collaborative problem-solving (CPS) assessment

In the 2012 OECD Programme for International Student Assessment (PISA), one of the components of the testing program included problem-solving assessment. This program measured general reasoning skills of 15-year-olds, and their willingness and ability to regulate problem-solving processes. The national report, Thinking it through: Australian Students' Skills in Creative Problem-solving, released by the Australian Council for Educational Research, concluded that Australian students performed better than expected in solving problems, as judged by their performance in mathematics in the main PISA survey conducted at the same time.

The draft conceptual frameworks for PISA 2015 (for Science, Reading, Mathematics, Collaborative Problem-solving) provide the theoretical underpinning for the PISA 2015 assessment in which 15-year-old students were tested in science, reading, mathematics and collaborative problem-solving.

The PISA 2015 Collaborative Problem-solving Framework defines the core skills as:

- collaboration: grounding, explanation, coordination, filling roles, perspective taking, audience design, argumentation, mutual regulation
- problem-solving: explore and understand, represent and formulate, plan and execute, monitor and reflect.

The draft collaborative problem-solving tasks for PISA 2015 vary in length and a number of tasks are used to obtain evidence across all indicators. It is intended that students, using pre-programmed responses, collaborate with an avatar (computer agent) and not with another student. Using an avatar with pre-programmed responses makes the automation of scoring and analysis much easier/simpler. The results of a Rosen and Tager 2013 study suggest that “by using computer agents in a CPS task the students were able to show their collaborative skills at least at the level of that of their peers who collaborated with human partners. However, … each mode of collaboration involves limitations and challenges” (Rosen and Tager, 2013: 27).

PROJECT AIMS

The project aimed to:

- identify existing high-quality, innovative assessment practice and create opportunities to partner with, and learn from, excellent practitioners from around the world
- enable the creation of a robust assessment framework to test collaborative problem-solving skill development and competency of Australian students
- develop and provide access to high-quality assessment tasks that elicit valid, reliable data on students' collaborative problem-solving skills
- provide an opportunity to explore the value of alternative modes of assessment to test other 21st century skills.

Report on achievement of project aims

- **Identify existing high-quality, innovative assessment practice and create opportunities to partner with, and learn from, excellent practitioners from around the world**

  The project has drawn together relevant research findings across national and international projects, exploring the nature and assessment of collaborative problem-solving, and has aligned these with the conceptual understandings, skills and processes of the Australian Curriculum general capabilities of Critical and Creative Thinking and Personal and Social Capability.

  The project has achieved a high level of success in sharing knowledge and expertise in online assessment of collaborative problem-solving skills, particularly with our educational partners, the Swedish Association of Local Authorities and Regions (SALAR), the National Council for Curriculum and Assessment (NCAA) Ireland, EAA and the technical partner Janison. This has created opportunities to learn from excellent practitioners from around the world. The professional sharing across ACARA and NSW DoE, along with the leaders and teachers in trial schools, has been substantial.

- **Enable the creation of a robust assessment framework to test collaborative problem-solving skill development and competency of Australian students**

  The proof of concept trial in July 2015 and the full trial in October 2015 provided rich information to confirm a practical method to assess collaborative problem-solving skills, using an interactive online environment.

  The analysis of the extensive complex data collected will provide insight into the validity and reliability of the data on student performance and the validity of the assessment framework. The analysis will allow an evaluation of the criteria and the levels in the marking rubric. It will also inform the evaluation of the automated scoring process in relation to the student actions and to their chat to test collaborative problem-solving skill development and competency of Australian students.

- **Develop and provide access to high quality assessment tasks that elicit valid, reliable data on students' collaborative problem-solving skills**

  The writing and online production of the tasks together with the creation of the ACCPSAF and the marking/scoring rubrics have enriched the understanding of how collaborative problem-solving may be addressed in online assessments.

  Four high quality assessment tasks were developed and embedded in a functional and highly engaging assessment environment. The tasks were successfully accessed by more than 2200 students during trialing. All schools participating provided high levels of enthusiasm for the project.

  Extensive data have been collected and final analysis of data collected will determine the validity and reliability of the tasks.

- **Provide an opportunity to explore the value of alternative modes of assessment to test other 21st century skills.**

  A unique aspect of the project was the simultaneous capture of students' actions and text responses while they were interacting with a partner, sometimes located in different schools and communities. The ability to capture students' thinking and communication with others, along with indicators of their level of knowledge and skills, has the power to transform models of assessment.

  There is general agreement within the project team and partners that the project has provided unique opportunities to explore alternative modes of assessment, and there has been considerable discussion of how the online environment might be employed to assess other general capabilities, particularly Information and Communication Technology Capability and other elements such as *Reflecting on thinking and processes* (Critical and Creative Thinking) and *Social awareness* (Personal and Social Capability).

THE DRAFT AUSTRALIAN CURRICULUM COLLABORATIVE PROBLEM-SOLVING ASSESSMENT FRAMEWORK

The elements for the draft Australian Curriculum Collaborative Problem-solving Assessment Framework (ACCPSAF) have been informed by the:

- Australian Curriculum: General capabilities selected for the purposes of this project including Critical and Creative Thinking (CCT) and Personal and Social Capability (PSC)
- criteria from the Assessment and Teaching of 21st century skills (ATC21S) Hesse et al (2012) tables for social skills and cognitive skills in collaborative problem-solving
- descriptions in the Five Strands presentation of the Collaborative Problem-solving Empirical Progressions (ATC21S, 2014)
- PISA 2015 draft Collaborative Problem-solving Framework.

Relationship to the Australian Curriculum general capabilities

Collaborative problem-solving relates particularly to two of the Australian Curriculum general capabilities, *Critical and Creative Thinking* and *Personal and Social Capability*.

The general capability of *Critical and Creative Thinking* is described in terms of the elements of inquiring, generating ideas, reflecting and analysing based on the works of a number of theorists including Bloom et al 1956, and Anderson and Krathwohl 2001.

Personal and Social Capability is described in terms of the elements of self-awareness, self-management, social awareness and social management. These are based on the five competencies (self-awareness, self-management, social awareness, relationship skills and responsible decision making) identified by the Collaborative for Academic, Social and Emotional Learning (CASEL) at the University of Illinois Chicago, founded by Goleman et al in 1994.

Relationship to the general capabilities learning continua

Learning continua are available for each Australian Curriculum general capability to describe the relevant knowledge, skills, behaviours and dispositions at particular points of schooling. Within each of the general capabilities, specific behaviours and dispositions have been identified and incorporated into each learning continuum as elements and sub-elements.

The learning continua for each general capability are based on the premise that students need opportunities to develop capabilities over time and across learning areas.

The Australian Curriculum Collaborative Problem-solving Assessment Framework for collaborative problem-solving has specifically been developed based on elements from *Critical and Creative Thinking and Personal and Social Capability*. See **Appendix A** for a copy of the draft Australian Curriculum Collaborative Problem-solving Assessment Framework.

The sub-elements of each capability have then been adapted and framework criteria developed as required to provide evidence in the context of the interactive online collaborative problem-solving tasks.

There is considerable commonality in the ideas expressed through the Australian Curriculum general capabilities continua for Critical and Creative Thinking and Personal and Social Capability and the ATC21S Collaborative Problem-solving Empirical Progressions (2014). The language used is different but ideas such as self-evaluation and negotiation are common to both.

The organisation of the framework

The criteria that describe the levels in the Australian Curriculum Collaborative Problem-solving Assessment Framework have been derived from a number of sources.

In the cognitive domain, the levels have been developed using the levels described in the Structure of the Observed Learning Outcome (SOLO) taxonomy as pre-structural, uni-structural, multi-structural, relational and extended abstract. This learning development has been applied to the indicators identified from the *Critical and Creative Thinking* elements as appropriate to the online collaborative problem-solving tasks.

In the social domain, the levels have been developed using the levels described in Krathwohl's taxonomy as receiving, responding, valuing, organisation and characterisation. This learning development has been applied to the indicators identified from the *Personal and Social Capability* elements as appropriate to the online collaborative problem-solving tasks.

These developmental taxonomies provide a theoretical underpinning for curriculum and assessment frameworks and a mechanism for evaluating learning outcomes.

An important consideration in developing the Australian Curriculum Collaborative Problem-solving Assessment Framework is that the levels identified for the criteria should be seen as relevant parameters for the tasks developed. This means that these levels would not necessarily reflect the levels identified for the Australian Curriculum general capabilities learning continua. The levels in the ACCPSAF are a hierarchy of descriptions of anticipated levels of performance of students on the task. They provide a vertical dimension describing student learning at a point in time. The criteria in the ACCPSAF have been developed to identify actions and communications made by the student in the collaborative completion of the task.

Table 1 provides an overview of the elements and sub-elements of the Australian Curriculum general capabilities and the indicators from the ACCPSAF.

Note: *The Creative and Critical Thinking* element of *Reflecting on thinking and processes* and the *Personal and Social Capability* element of *Social awareness* are not substantially reflected in the Australian Curriculum Collaborative Problem-solving Assessment Framework.

Table 1: Relationship between the Australian Curriculum general capabilities and the Australian Curriculum Collaborative Problem-solving Assessment Framework (ACCPSAF) indicators

Australian Curriculum general capability		**Australian Curriculum Collaborative Problem-solving Assessment Framework**	**Australian Curriculum general capability**		**Australian Curriculum Collaborative Problem-solving Assessment Framework**
Critical and Creative Thinking			***Personal and Social Capability***		
Element	**Sub-element**	**Indicator**	**Element**	**Sub-element**	**Indicator**
Inquiring-identifying, exploring and organising information and ideas	Pose questions	Poses questions, clarifies	Self-awareness	Recognise emotions	
	Identify and clarify information and ideas	Collects and organises information		Recognise personal qualities and achievements	
	Organise and process information			Understand themselves as learners	Describes their learning
Generating ideas, possibilities and actions	Imagine possibilities and connect ideas	Suggests actions and ideas Considers alternatives		Develop reflective practice	Reflects on actions and communications
	Consider alternatives		Self-management	Express emotions appropriately	
	Seek solutions and put ideas into actions			Develop self-discipline and set goals	Uses self-discipline and sets goals
Analysing, synthesising and evaluating reasoning and procedures	Apply logic and reasoning	Analyses the problem /task Applies logic to developing a solution Draws conclusions		Work independently and show initiative	Works independently and shows initiative
	Draw conclusions and design a course of action			Become confident resilient and adaptable	
	Evaluate procedures and outcomes		Social-management	Communicate effectively	Communicates effectively
				Work collaboratively	Works collaboratively
				Make decisions	Makes decisions
				Negotiate and resolve conflict	Negotiates and resolves conflict
				Develop leadership skills	Demonstrates leadership skills

DESIGN OF THE TASKS AND THE ONLINE ENVIRONMENT

The Collaborative problem-solving online assessment and the Australian Curriculum project includes the design of tasks, their rubrics and the development of a dedicated online environment.

> For assessment design, the framework must consider the kinds of constructs that can be reliably measured, and must provide valid inferences about the collaborative skills being measured and about their impact on success in today's world. (OECD, 2013)
>
> Tasks must be carefully designed to provide evidence that is linked to the cognitive model of learning and to support the kinds of inferences and decisions that will be made on the basis of the assessment results. (Pellegrino, 2009)

A critical aspect of the task design has been the desire to assess the collaboration between two students completing a task in a manner that reflects authentic situations, in classrooms and in the workplace, where there is increasing need to work collaboratively online to solve problems.

The design of the tasks has taken into account other possible applications including the tasks being made available to schools to assess and track learning and individual progress of general capability development. Data from the tasks could provide a tool to validate teacher judgment and make school-based assessment of collaborative problem-solving more meaningful beyond the school.

The development of the online environment has been informed by a range of approaches to measuring collaborative problem-solving.

In a standard assessment model such as ACARA's National Assessment Program – Literacy and Numeracy (NAPLAN), data are obtained from discrete responses from a number of predefined test items that are generally scored on the basis of correct or incorrect responses. Inferences on student proficiency are made from these data using classic test theory referring to a specific domain from which the items have been developed.

In the assessment of collaborative problem-solving, the observable evidence is not an answer to a discrete pre-packaged item or question, but a response toward solving a problem. Activity logs of educational software are used to collect data. These describe the actions and interactions of the students involved in the task. While the data can be captured, the analysis of that data is challenging. Current psychometric methods are not considered appropriate for this type of data particularly in relation to statistical independence. New analytical methods are required.

In her 2013 paper *Collaborative Problem-solving and the Assessment of Cognitive Skills: Psychometric Considerations,* von Davier suggests how these issues could be overcome. Von Davier and her collaborators indicate they intend to only measure the cognitive skills in a task where students are collaborating in a problem-solving context. This would allow them to establish the psychometric model rather than trying to directly measure the collaboration.

Care and Griffin indicate that 'validation of the approach has occurred ... through face validity exercises with teachers and students, and then through statistical analysis of coded data and its modelling' (Care and Griffin, 2014: 386).

Care and Griffin utilised activity logs or log-files, the time-stamped record of what a program does and the detail of the student's activity. Log-files can be used to describe actions and interaction referred to as process data, but there are also outcome data.

Statistical models should accurately describe the dynamics of the interactions between the two students. Indicators and criteria from the ACCPSAF will provide the means to create scoring rules. Outcome data may be collected where it provides evidence for collaborative problem-solving skills.

The research from this project will enable the collection of empirical data on student performance as well as in relation to the performance of tasks. This will enable psychometric investigation of task performance including the ability to construct the psychometric scale to assess and report on these complex skills.

The tasks

The Australian Curriculum Collaborative Problem-solving Assessment Framework describes the capabilities required for the collaborative problem-solving tasks. See **Appendix B** for a summary of the four tasks involved in the full October trial.

The tasks have been designed to have a social focus and be dynamic and interactive in nature. The problem needs to be age-appropriate and well-defined, containing some ambiguity and having a rich, real-world context.

For the purpose of this assessment, it was designed on the basis that the problem cannot be solved independently and that the collaboration of the partners is essential. Students should have the cognitive and social skills required to complete the task based on the content from the Australian Curriculum for Years 6, 7, 8 and 10.

Two students work together to a common goal and they are linked by a team code. Interdependency is high. Rosen and Tager (2013) suggest that in the case of a student-to-student pairing, asymmetry in roles may occur as one student takes on the role of a leader. In our tasks, there is a presumed symmetry of status, knowledge and roles with a shared problem space.

While all the information needed to solve the problem is provided to the pair, each individual student will not have all the information. The tasks are interactive and some exploration of how to use the tools may be required in order to solve the problem successfully.

Students:

- explore and identify the problem
- share and collect information
- identify patterns and links between elements and partners
- plan and set up rules collaboratively
- monitor process collaboratively
- reflect and challenge collaboratively.

The tasks provide sufficient opportunity to generate data that would allow the interpretation of a student's performance. Although there is a context for each of the tasks, care has been taken to ensure that no requisite knowledge is needed to complete the tasks. The tasks have been scaffolded into several parts. As the tasks progress, each part demands greater levels of problem-solving and collaboration skills.

To maximize data for research and development, an assessment session begins with a survey of the students' attitudes to solving problems and working with others, and ends with a survey of their responses to the tasks and to working with their partners. See **Appendix D** for a copy of the pre- and post-survey questions.

One of the tasks is described below. See **Appendix C** for the scoring rubric for Task 1: Lights out.

Year 8: Lights out

The task is set around the problems associated with using electrical equipment. Care has been taken that only basic knowledge of electric circuits, as experienced in the home and assumed as known by primary school students, is needed to complete the task.

Initially the student is introduced to the task through a virtual scenario of being faced with a darkened room and the student is set the challenge to determine the functionality of a range of electrical components.

The student begins the task individually setting up a circuit based on instructions This is intended to develop a student's familiarity with, and skills in, the online environment. From this point forward, the student can interact with a partner, using the chat box, to share thoughts and ideas that contribute to solving the problems. Each student is only in control of some of the components and settings, so they must work collaboratively in order to solve the problems. Various parts of the task require the manipulation of the settings of several components to produce the brightest light and to determine which of the components are working and which are faulty.

The online environment and the scoring process

The online environment for the delivery of the tasks has been developed by the technical partner, Janison. Each task typically requires about 10–15 minutes for completion. Students access the environment via the internet. Students have a personal log-in. The system uses conventional media such as diagrams, figures, tables, simulations, windows, icons and possibly multiple-choice items. Students interact via a chat box. Words that would be appropriate and relevant are provided to assist communication, simulating a predictive text tool. Students use conventional interface components such as a mouse click, slider, drag-and-drop, cut-and-paste and type text. Tasks involve subsets or parts that require multiple pages/screens.

A unique aspect of the environment was simultaneous capture of students' actions and text responses while they were interacting with a partner, sometimes located in different schools and

communities. The ability to capture students' thinking and communication with others, along with indicators of their level of knowledge and skills, has the power to transform models of assessment.

An evaluation engine is built into the design of each task. This enables the students' work to be analysed in real time, awarding achievements at specific levels for indicators based on criteria defined in the task design. A key innovation in this approach is a model to allow tasks to continuously score via indicators and levels throughout the actual collaborative process. Actions within the space, as well as communications in the chat box are also recorded to allow the use of algorithms to code and rescore direct actions and provide metadata from the chat box. This provides the mechanism for measuring students' collaborative problem-solving skills.

Four tasks have been developed, which embed these skills in a variety of contexts. The task and scoring system provide the opportunity to measure the collaborative problem-solving skills of students as distinguished from the context.

Standard actions such as a mouse click or drag-and-drop are automatically scored as a level between 1 and 5, and the student interactions (text in chat box) are used to validate the data. Appropriate and relevant words in the chat box are coded and scored, while extensive text in the chat is not scored.

For each task, a scoring rubric has been developed based on the levels in the framework identifying specific student actions and their responses in the chat box. See **Appendix C** for a copy of the scoring rubric for Task 1: Lights out.

TRIALLING AND PRELIMINARY FINDINGS

A proof of concept trial of one task was conducted in July 2015 with 900 Year 9 students in nine NSW schools, where students are experienced in online testing using a similar environment. The trial schools were selected to provide representative samples of students.

In October 2015 a full trial of four tasks was conducted in 20 schools (across urban, regional and remote locations) from five Australian states and territories with over 2,200 Year 8 students (approximately 14 years old). Data captured from the trial provide the evidence to locate students on the levels proposed in the assessment rubric. The trial included a cognitive interview process to provide additional information to developers about the design of the tasks and particularly about the coding. The cognitive interview process also provided information about the pairing processes and its success.

Observations from the trial

Observations were recorded at all trial sessions in the following areas: student engagement and teacher/school support, technical issues (in the school and in the online environment), pairing and timing.

Student engagement and teacher/school support

Based on anecdotal evidence provided by teachers, observers and survey data, the vast majority of the students who took part in the trial were fully engaged in the process and enjoyed the tasks. The assessment was undertaken by Year 8 students; however, there may be benefit in trialing with younger and older students. Staff were generally very supportive and helpful during the trial process. Some schools were eager to have their students participate and to find out how their students responded to the challenge.

Technical issues

About half of the schools experienced some technical problems related to the computers that were being used or the system used to access the internet. For example, where the students brought their own devices, these were not always well-maintained with up-to-date software and settings. Although a number of schools used Wi-Fi to access the internet, this worked efficiently in some schools but not in others. With the initial schools during the trial, some issues were experienced with the online environment. Some of these issues were rectified later in the trial.

Timing

For most of the schools involved, small numbers of students were able to complete all tasks in a reasonable time. Issues that contributed significantly to this overrun of the timing related to available computers and to students dropping out of a pairing situation and having to log back in.

Random pairing

In the PISA 2015 draft collaborative problem-solving tasks, students collaborated with an avatar (computer agent) using pre-programmed responses and not with another student. The advantage of using an avatar with pre-programmed responses is that it makes for much easier/simpler automation of scoring and analysis; however, it is labour-intensive for developers.

To make the tasks more economically sustainable and to avoid the complexity of selecting working pairs, the project partners were particularly interested in the viability of students being paired randomly across schools via the online environment. It was presumed there was a symmetry of status, knowledge and roles with a shared problem space.

Students were paired randomly and across schools where possible. It was technically difficult to ensure students were paired across schools and to maintain consistent pairing as students were easily able to drop out of their pairing situations. There were a small number of selected pairings as part of the cognitive interview process.

The selection process for working pairs may be varied in future trialing to investigate the effect of random pairing versus selected pairing.

Cognitive interview process

The cognitive interviews in this research activity focused on the cognitive and social skills that students used to solve the problems presented in the tasks. Information was collected on students' interaction and engagement with the four assessment tasks and in particular students' feedback about the interaction between the two students. Interviews examined the extent to which the online tasks assess knowledge and skills not easily assessed by more common testing programs. The cognitive interviews were conducted by an external consultant, Education Assessment Australia (EAA).

EAA reported that:

> Though all students interviewed used computers regularly both at home and school, the level of technological sophistication in the assessment came as a pleasant surprise to most… Their satisfaction with the collaborative aspect of the assessment was most pronounced where they had a partner who was responsive and able, and being paired with a partner who was less able or disengaged could be "*frustrating*"…. Chat-based communication with a partner in the form of typing was not problematic… Though not specifically designed as a measure of a student's capacity for effective micro learning, the game- or puzzle-like nature of the tasks was frequently observed to involve significant amounts of micro learning in order to complete them.
> (EAA, 2015: 12)

Micro-learning referred to in the EAA report can be considered as part of the problem-solving process described as barriers by Frensch and Funke (1995). They describe the 'givens' as the knowledge that the student has about the problem at the outset and 'barriers' as lack of knowledge, process or strategies that stand in the way of achieving the solution.

The barriers must be overcome using the available tools in the assessment. The data may provide further insights into the impact of micro learning on collaborative problem-solving.

The findings from the cognitive interviews will assist in validating the four tasks and the Australian Curriculum Collaborative Problem-solving Assessment Framework.

Student survey report

In the full trial held in October, students were asked to complete a survey before commencing the collaborative problem-solving tasks and again on completion of the four tasks. See **Appendix D** for pre- and post-survey questions and data analysis.

A preliminary analysis of responses to the student survey has been conducted. Sixty-nine per cent of students who completed the pre-survey indicated they enjoyed solving problems. Ninety-six per cent of the students agreed that it was important for students to learn to solve problems, and 71 per cent thought that it was important to work with others using an online environment. Eighty-eight per cent of students thought that working with a partner helped them to solve problems; however, 56 per cent of them said that they worked with a partner to solve problems in class.

From the post-survey, 74 per cent of students indicated they enjoyed solving the problems in the tasks, and 88 per cent of the students liked using the chat box. Unexpectedly, 82 per cent of students felt that they worked through the problems in an organised way. Over 70 per cent of students responded that they suggested ideas to their partner, and understood and used the ideas of their partner to help solve the problems in the tasks.

When asked which of the tasks they favoured the most, 43 per cent of the students selected Task 2: Let's tackle the fish problem. Interestingly, 58 per cent of students responded that they selected their favourite task because it was the most interesting, with only 28 per cent selected the task because it was the easiest.

See **Appendix D:** Student survey report.

Further work (to complete the project)

The project has collected a large and complex data file capturing individual students' actions and responses in text files. Janison has completed initial data-cleansing according to an agreed data analysis model. The analysis of data from the October trial has not yet been completed. Currently the psychometric team are investigating methods for final analysis. There may need to be a number of models applied to the data to determine the most effective method to assess student levels of achievement in collaborative problem-solving. This ground-breaking work is likely to be completed by October 2016; the early indicators are that the tasks will provide valid and reliable data. The final analysis will provide data for triangulation of student attributes of learning and will provide excellent and extensive data to validate the framework.

A more complete analysis of the survey data will make it possible to compare the responses of different groups of students. This would provide valuable information about whether, for instance, students who felt that they worked through problems in an organised way were

successful in solving the problems in the tasks; or whether students who felt that they had suggested ideas themselves and used the ideas of others rated highly in the social domain. This sort of information would be very useful to teachers and students in providing feedback on their learning of how to solve problems collaboratively.

Following reporting of the final data analysis, the project team will refine the task, their rubrics and the Framework. Following further negotiation between partners, the data collection environment may be refined to allow new tasks to be developed and trialed against the refined framework. A final report will be available by December 2016.

CONCLUSIONS AND FUTURE DIRECTIONS

This project built on the work of the Assessment and Teaching of 21st Century Skills Project (ATC21S) and PISA 2015 Collaborative Problem-solving (CPS) assessment to develop an assessment framework aligned to the Australian Curriculum context and to identify further areas for development and research.

The project itself has been a collaborative problem-solving process. Across the project partners, diverse expertise has been drawn upon in curriculum, assessment frameworks, task design and online learning and assessment. The project has built productive relationships and new learning through our work with international partners.

The development of the Australian Curriculum Collaborative Problem-solving Assessment Framework reflects the important interdependencies that exist between the curriculum, what is taught, and the assessment of what students learn. At this stage of the analysis of data, it is too early to determine if the Framework may have applications beyond the life of the project. It seems likely, however, that the data from the trial will be used to validate the Framework and support future verification of aspects of the Australian Curriculum general capabilities, including their strength in describing collaborative problem-solving.

The tasks themselves provide illustrations of new and more sophisticated assessments that may be developed for use in the Australian National Assessment Program or could be used in local contexts to strengthen teacher judgment and moderate school-based assessment. The data collected during the trial, both through the online assessment and the survey, can be used to inform future task development.

A critical aspect of the project has been the desire to assess collaboration and problem-solving between students completing tasks in more authentic situations. The need for further research to achieve this goal is evident, in particular in terms of selecting working pairs such as the effect of random pairing versus selected pairing as well as the impact of age and maturity on engagement and collaboration.

The provision of effective online assessment of collaborative problem-solving is a shared global challenge. It is clear from this project that there is great potential but there is still more to be investigated.

REFERENCES

ACARA (2013). Australian Curriculum: General capabilities www.australiancurriculum.edu.au/generalcapabilities/overview/general-capabilities-in-the-australian-curriculum

Anderson, Lorin, W and Krathwohl, DR 2001, *A Taxonomy for Learning, Teaching and Assessing: a Revision of Bloom's Taxonomy*, New York, Longman Publishing.

Care, E and Griffin, P 2014, An approach to Assessment of Collaborative Problem Solving, *Research and Practice in Technology Enhanced Learning*, vol.9, No. 3, pp. 367–88, Asia-Pacific Society for Computers in Education. www.apsce.net/uploaded/filemanager/8daf89d5-ac51-450f-aa4e-f4efef848834.pdf

Collaborative for Academic, *Social and Emotional Learning* (CASEL) at the University of Illinois, Chicago, CASEL.

Delors, J 1996, *Learning the Treasure Within: Report of the International Commission on Education for the Twenty-first Century,* UNESCO.

Educational Assessment Australia (EAA) 2015, *Collaborative Problem Solving Online Assessment 2015 Trial: Cognitive Interviews Report*, unpublished.

Frensch, PA and Funke, J (eds) 1995, *Complex Problem Solving. The European Perspective,* New York: Psychology Press.

Griffin, P, Robertson, P 'Writing Assessment Rubrics', Griffin, P 2014 (ed), *Assessment for Teaching*, New York: Cambridge University Press.

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

McGaw, B 2013, *Developing 21st Century Competencies through Disciplines of Knowledge,* Paper presented at the International Symposium on Education and 21st Century Competencies, Muscat, Sultanate of Oman, 22–24 September 2013.

Ministerial Council on Education, Employment, Training and Youth Affairs, 2008, *Melbourne Declaration on Educational Goals for Young Australians*.

Pellegrino, J December 2009, Exploratory Seminar: *Measurement Challenges Within the Race to the Top Agenda,* New Jersey, USA.

OECD 2013, PISA 2015, *Draft Collaborative Problem Solving Framework,* PISA, OECD Publishing.

OECD 2014, *PISA 2012 Results: Creative Problem Solving: Students' Skills in Tackling Real-Life Problems vol. V,* PISA, OECD Publishing.

Rosen, Y, Tager, M 2013, *Computer-Based Assessment of Collaborative Problem Solving Skills: Human-to-agent versus human-to-human approach*. Boston, MA, Pearson Education. http://researchnetwork.pearson.com/wp-content/uploads/CollaborativeProblemSolvingResearchReport.pdf

Von Davier, A and Halpin, P, 2013, '*Collaborative Problem Solving and the Assessment of Cognitive Skills: Psychometric Considerations*'. Research Report ETS RR-13-41.

APPENDIX A: DRAFT AUSTRALIAN CURRICULUM ASSESSMENT FRAMEWORK FOR COLLABORATIVE PROBLEM-SOLVING

Draft Australian Curriculum Assessment Framework for Collaborative Problem-solving tasks – Social domain							
Based on Australian Curriculum: General capability (Personal and Social Capability)							
Element	**Outcome**	**Indicator**	**Criteria (Level based on Krathwohl's taxonomy)**				
			Level 1 **Receiving – listening**	**Level 2** **Responding – actively responding to**	**Level 3** **Valuing – to support ideas**	**Level 4** **Organising – to harmonise**	**Level 5** **Systemising – to resolve**
Self-awareness SEA	Students assess their strengths and weaknesses	Describes their learning C (a)	Identifies their talents/interests	Notes own performance	Identifies factors that could block progress in a task		
		Reflects on actions and communications C (b)	Identifies their strengths	Notes performance of others	Tracks their progress in a task	Seeks and responds to feedback from others Provides feedback to others	Identifies expertise available and relevant to task
Self-management SEM	Students set goals and work toward their achievement	Uses self-discipline and sets goals A (a)	Takes action	Follows simple instructions	Follows complex instructions	Makes a plan/ sets goals	Changes plans/actions
		Works independently and shows initiative A (b)	Maintains a presence	Identifies a task	Attempts a task	Perseveres in a task	Completes tasks successfully

Draft Australian Curriculum Assessment Framework for Collaborative Problem-solving tasks – Social domain							
Based on Australian Curriculum: General capability (Personal and Social Capability)							
Element	**Outcome**	**Indicator**	**Criteria (Level based on Krathwohl's taxonomy)**				
			Level 1 Receiving – listening	**Level 2 Responding – actively responding to**	**Level 3 Valuing – to support ideas**	**Level 4 Organising – to harmonise**	**Level 5 Systemising – to resolve**
Social-management SOM	Students coordinate and resolve potential differences in viewpoints, interests and strategies	Communicates effectively C (a)	Attempts communication Responds with little, irrelevant or incorrect information	Responds appropriately	Generates appropriate communication re context, self and others	Generates and responds to communication relevant to task requirements and constraints, clarifying problems	Initiates communication re deficits in common understandings
		Works collaboratively A (b)	Is active in group activity	Responds to cues in information	Adapts activity based on contributions from others	Initiates and promotes interaction	Makes proposals to benefit the group Assumes group responsibility
		Makes decisions C (c)	Identifies needs	Identifies relevant criteria	Recognises or contributes ideas/results	Contributes to a group decision	Evaluates the outcome of a decision
		Negotiates and resolves conflict C (d)	Listens to the ideas of others	Comments on differences in perspectives	Clarifies different ideas and viewpoints	Suggests a compromise or alternative position	Achieves a resolution
		Demonstrates leadership skills A (e)		Takes responsibility for a task or an action	Supports partner	Assigns or confirms roles	Initiates a team change when appropriate

Draft Australian Curriculum Assessment Framework for Collaborative Problem-solving tasks – Cognitive domain							
Cognitive domain – Critical and Creative Thinking general capability							
Element	**Outcome**	**Indicator**	**Level (1)**	**Level (2)**	**Level (3)**	**Level (4)**	**Level (5)**
Inquiring (CI)	Students identify, explore and organise information	Pose or clarifies questions (a)	Poses a question	Poses a relevant clarifying question	Identifies the information needed	Interprets the information provided	Explains the need for the information
		Collects and organises information (b)	Uses an element of information	Uses isolated pieces of information	Uses relevant elements of information	Uses links in relevant information from a number of sources	Combines and uses relevant information from a number of sources
Generating (CG)	Students generate ideas, possibilities and actions	Suggests actions/ ideas (a)	Uses trial and error actions	Suggests an idea/action to approach a task	Uses actions in logical / purposeful sequence	Compares ideas/actions as solutions to task	Uses a systematic approach to action sequence
		Uses resources (b)	Uses a resource without consultation		Uses resources appropriately	Allocates resources	Initiates alternative resource or use
		Considers alternatives (c)	Takes inappropriate action in an ambiguous situation		Acts appropriately and notes ambiguity		Acts on possible alternative solutions or sequences

Draft Australian Curriculum Assessment Framework for Collaborative Problem-solving tasks – Cognitive domain							
Cognitive domain – Critical and Creative Thinking general capability							
Element	**Outcome**	**Indicator**	**Level (1)**	**Level (2)**	**Level (3)**	**Level (4)**	**Level (5)**
Analysing (CA)	Students analyse, synthesise and evaluate	Analyses the problem/task (a)	Identifies/ acts on the problem as stated	Identifies/acts on possible steps to solution	Acts on an organisation of the problem/task into sub-tasks		Acts on a sequence of steps/actions
		Applies logic to developing a solution (b)	Takes action without knowledge /consideration of logical consequence		Takes an action using an understanding/ consideration of the logical consequence	Implements a course of action using understanding/ consideration of logical consequences	Draws conclusions based on a series of logical consequences

APPENDIX B: SUMMARY OF THE FOUR TASKS

Task 1: Lights out

Students are provided with the following scenario: Most devices that we use every day contain electrical circuits to make them work. Sometimes they don't work properly for a variety of reasons.

Students work with their partner to identify problems and find solutions to make circuits work and keep the lights on.

Task 2: Let's tackle the fish problem

Students are provided with the following scenario: The water in the creek is polluted. Fish are dying. We believe it is the pollution that is killing the fish.

Students work with their partner to identify the condition causing the pollution and where it is coming from, so they can fix the problem.

Task 3: Who's got your vote?

Students are provided with the following scenario: Voting occurs in local settings (such as a school election for captains), at sporting clubs (for people to chair committees) and at the government level (for members of parliament including premiers and Prime Minister). In democratic elections, the winner is the candidate with the most votes. For a democratic election to be fair, all votes must be counted.

Students work with their partner to undertake different forms of voting that are commonly used in a variety of situations.

Task 4: Where the wind blows

Students are provided with the following scenario: A wind farm is a collection of wind turbines in one location. Wind power can be used to generate electricity and reduce carbon emissions. Wind turbines capture wind energy to produce electricity.

Students work with their partner to build a wind farm to supply energy to an island in the Celtic Sea.

APPENDIX C: SCORING RUBRIC FOR TASK 1 – LIGHTS OUT

Evidence for elements and indicators for collaborative problem-solving Task 1: Lights Out

Part A: Constructing a circuit

An individual student constructs the circuit by dragging and dropping the parts to the appropriate positions. Coded as:

Self-management (SEM)						
Students set goals to work towards their achievement	**Uses self-discipline and sets goals (a) A/C**	**Takes action**	**Follows simple instructions**	**Follow complex instructions**	**Makes a plan / sets goals**	**Analyses set goals**
		Something moves to a location (SEMa1)	Drags components to correct locations – 4 actions (SEMa2)	Rotates components to make all parts connect – 4 actions (SEMa3)		

First use of chat box: students introduce themselves to their partner

Social management (SOM)						
Coordinate and resolve potential differences in viewpoints, interests and strategies	**Communicates effectively (a) C**	**Attempts communication or responds with little, irrelevant or incorrect information**	**Responds appropriately**	**Generates appropriate communication re context, self and others**	**Generates and responds to communication relevant to task requirements & constraints, clarifying problems**	**Initiates communication re deficits in common understandings**
		Something typed in chat box but not using any predictive text (SOMa1)	Responds in chat-box with appropriate greeting, using Hello, hi, my name (SOMa2)	In chat-box generating communication 'how you, who you, where you, what you' (SOMa3)		

Part B: Simple brightest setting

Students interact with each of their components and use the chat room to determine the settings that produce the brightest light. Student 1 can change the setting box and student 2 can change the switch only. They record their settings using two drop down menus.

Self-management (SEM)						
Students set goals and work toward their achievement	**Work independently and show initiative (b)**	**Maintains a presence**	**Identifies a task**	**Attempts a task**	**Perseveres in a task**	**Completes a task successfully**
		Interacts with their components (SEMb1)		Both partners interact with components (SEMb3)	All settings were tried by both partners (SEMb4)	Identifies correct combination of settings (SEMb5)

Social management (SOM)						
Coordinate and resolve potential differences in viewpoints, interests and strategies	**Work collaboratively (b) A/C**	**Is active in group activity**	**Responds to cues in information**	**Adapts activity based on contributions from others**	**Initiates and promotes interaction**	**Makes proposals to benefit the group or assumes group responsibility**
		Changed settings on a component (SOMb1)	Tests a setting in response to a chat box suggestion (SOMb2)	Changed settings on both components (SOMb3)		In the chat-box 'we should/could…' (SOMb5)
	Communicate effectively (a) C	Attempts communication or responds with little, irrelevant or incorrect information	Responds appropriately	Generates appropriate communication re context, self and others	Generates and responds to communication relevant to task requirements & constraints, clarifying problems	Initiates communication re deficits in common understandings

		In the chat-box 'Hi, hello, who' (SOMa1)	In the chat-box 'My switch up/down' or 'My setting box circle, triangle, square, star' (SOMa2)	In the chat-box 'Your switch up/down' or 'Your setting box circle, triangle, square, star' (SOMa3)	In the chat-box 'How dim/bright' or 'When dimmest/brightest' (SOMa4)	

Cognitive – generating (CG)						
Students generate ideas, possibilities and actions	**Suggests actions and or ideas (a) A/C**	**Uses trial and error actions**	**Suggests an idea/action to approach a task**	**Uses actions in logical/purposeful sequence**	**Compares ideas/actions as solutions to task**	**Uses a systematic approach to action sequence**
		Some settings were tried in each part (CGa1)	In the chat box 'Check your/my settings' (CGa2)	Switch turned on (CGa3)	Both partners use chat box 'Change your/my settings' (CGa4)	Records correct combination of settings (CGa5)

Part C: Complex brightness settings

Students use the chat box to share information about their settings with their partner as they can only see the settings on their own switch and settings box. From this they need to determine:

i) Which settings make the lamp go on.

ii) Which settings on the settings boxes make the lamp shine brightest.

Social management (SOM)						
Coordinate and resolve potential differences in viewpoints, interests and strategies	**Work collaboratively (b) A/C**	**Is active in group activity**	**Responds to cues in information**	**Adapts activity based on contributions from others**	**Initiates and promotes interaction**	**Makes proposals to benefit the group or assumes group responsibility**
		Changed settings on a component (SOMb1)	Tests a setting in response to a chat box suggestion (SOMb2)	Changed settings on both components (SOMb3)		In the chat-box 'We should/could…' (SOMb5)
	Communicate effectively (a) C	**Attempts communication or responds with little, irrelevant or incorrect information**	**Responds appropriately**	**Generates appropriate communication re context, self and others**	**Generates and responds to communication relevant to task requirements & constraints, clarifying problems**	**Initiates communication re deficits in common understandings**
		In the chat-box 'Hi, hello, who' (SOMa1)	In the chat-box 'My switch up/down and My setting box circle, triangle, square, star' (SOMa2)	In the chat-box 'Your switch up/down' and 'Your setting box circle, triangle, square, star' (SOMa3)	In the chat-box 'How dim/bright?' or 'When dimmest/brightest?' and 'When on/off?' (SOMa4)	In the chat-box 'What if?' (SOMa4)

Cognitive – inquiring (CI)						
Students identify, explore and organise information	**Collects and organises information (b) A**	**Uses an element of information**	**Uses isolated pieces of information**	**Uses relevant elements of information**	**Uses links in relevant information**	**Combines and uses relevant information from a number of sources**
		Changes settings for one component (CIb1)	Changes settings on all components (CIb2)	Records correct combination of settings for switches (CIb3)	Produces the brightest lamp (CIb4)	Records correct combination of settings for both components (CIb5)

Part D: Finding faults

In this part each student has two light bulbs (different), settings box and a switch. Students can drag and drop components into their section of the circuit (indicated by blue and red regions) Students need to work systematically to determine which components are faulty and which are working and drag them to the correct positions. One of the bulbs is broken for each person and either the settings box or switch.

Social management (SOM)						
Coordinate and resolve potential differences in viewpoints, interests and strategies	**Make decisions (c)**	**Identifies needs**	**Identifies relevant criteria**	**Recognises or contributes ideas or results**	**Contributes to a group discussion**	**Evaluates the outcome of a decision**
		Places one component in the circuit (SOMc1)	Tests all components for the circuit (SOMc2)	In the chat-box My switch working/faulty and My setting box working/faulty and My bulb working/faulty/not working/broken (SOMc3)	Correctly identifies their own faulty and working components (SOMc4)	
Cognitive - Analysing						
Students analyse, synthesise and evaluate	**Applies logic to developing a solution (b)**	**Takes action without knowledge or consideration of logical sequence**	**Takes an action considering the consequence**	**Takes a series of actions considering the consequences**	**Designs a logical course of action**	**Makes generalisations or evaluates plausible solutions**
		Tests some components (CAb1)	Correctly identifies one faulty component (CAb2)	Correctly identifies both faulty components (CAb3)	Correctly identifies faulty component for each person (CAb4)	In the chat-box If part faulty/not working/ broken then light won't glow/work/shine (CAb5)

APPENDIX D: STUDENT SURVEY DATA ANALYSIS

Pre-survey

Student pre-survey completed prior to commencement of tasks.

Survey items	**Percentage**			
	Strongly disagree	**Disagree**	**Agree**	**Strongly agree**
It is important for students to learn ways to solve problems	2	2	53	43
Working with a partner helps me to solve problems	3	9	63	25
It is important to work with others using an online environment	3	26	64	7
I enjoy solving problems	6	25	55	14
	Rarely	**Sometimes**	**Often**	**Always**
I work with a partner to solve problems in class	6	38	47	9

Note: The percentages provided in the table are the percentage of those students who responded. 28.8 per cent of the total number of students participating did not respond to the pre-survey questions.

Post-survey

Student post-survey completed after the completion of the tasks.

Survey items	**Percentage**			
	Strongly disagree	**Disagree**	**Agree**	**Strongly agree**
I enjoyed solving the problems	8	18	59	15
I liked using the chat box	4	8	44	44
I worked through problems in an organized way	5	13	68	14
	Rarely	**Sometimes**	**Often**	**Always**
I suggested ideas to my partner to help solve the problems	6	23	46	25
I understood my partner ideas and information	7	14	43	36
I used ideas from my partner to help solve the problems	6	21	46	27
	Task 1	**Task 2**	**Task 3**	**Task 4**
Which task did you enjoy the most?	29	43	20	8
	Most interesting	**Easiest**	**Most challenging**	**Most familiar**
Why did you select this task as your favourite?	58	28	5	9

Note: Task 1: Lights out; Task 2: Let's tackle the fish problem; Task 3: Who's got your vote?; Task 4: Where the wind blows.

The percentages provided in the table are the percentage of those students who responded. 59 per cent of total number of students participating did not respond – this was in part due to a technical problem on one day when students were unable to complete and students not completing the fourth task.