PISA 2021 and Beyond:
Design and Development of Innovative Learning and Assessment Solutions for Creative Thinking

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Higher-order skills such as, creativity, critical thinking, and computational thinking transform lives and drive economies. However, measuring these skills by using traditional assessment methods is a challenging task. Recent advancements in technology, learning science, cognitive psychology, and educational assessment enable the development of innovative measurement methods for higher-order skills. This paper offers insights regarding the design and development of innovative learning and assessment solutions for creative thinking. Topics explored include the broader conceptualization of the construct of creative thinking in the context of learning and assessment and the resulting implications for task design and development. Sample item and cognitive lab insights are highlighted and possibilities for further refinement are explored.

Keywords: creative thinking, innovative assessment, learning solutions

Introduction/Background:

Transferable and cross-cutting higher-order skills such as creativity, critical thinking, and computational thinking transform lives and drive economies. However, measuring these skills using traditional assessment methods is a challenging task. Recent advancements in technology, learning science, cognitive psychology, and educational assessment enable the development of innovative measurement methods for higher-order skills.

Creative Thinking stands out among the higher order thinking skills due to its potential to facilitate the creation of the new insights and innovations that will be required to solve major global challenges. It's capacity to facilitate the wave of innovation created by the merging of minds, industries, and fields as part of the 4th industrial revolution further highlights its potential and value for society as a whole.

The importance of Creative Thinking skills specifically is highlighted by the selection of Creative Thinking as the Innovative domain for the 2021 Programme for International Student Assessment (PISA) by the Organisation for Economic Co-operation and Development (OECD). Creative Thinking is also highlighted as a critical component of the transformative competencies of OECD's Education 2030 initiative (OECD, 2018); the trends established by the OECD Centre for Educational Research and Innovation (CERI); and the essential role of Creative Thinking in achieving many of the seventeen Sustainable Development Goals outlined by the United Nations in the United Nations Sustainable Development Goals (UNSDGs) work.

The development of an assessment to measure creative thinking requires the ability to parse and define and measure the essential competencies and processes required for creative thinking. Attempts to achieve this type of definition and measurement at scale have been limited and the most notable work in this space has been achieved through the development of a Creative Thinking Framework and Assessment by the OECD for PISA 2021.

Creative thinking is defined in the PISA 2021 Creative Thinking Framework as *the competence to engage productively in the generation, evaluation and improvement of ideas that can result in original and effective solutions, advances in knowledge, and impactful expressions of imagination* (OECD, 2019). This definition is also in line with the definition of creative thinking put forth by the Creative Thinking Strategic Advisory Expert Group (OECD, 2017).

The domain is focused on 3 primary facets:

- **Generate Diverse Ideas**
  - Focuses on students' capacities to think flexibly across domains
- **Generate Creative Ideas**
  - Focuses on students' capacities to search for appropriate and original ideas across different domains
- **Evaluate and Improve Ideas**
  - Focuses on students' capacities to evaluate limitations in given ideas and find original ways to improve them

The limitations of this definition and assessment are rooted in the contextualization of this framework for the educational background and large scale assessment constraints relevant for 15 year olds around the world. The conceptualization and assessment make efforts, however,

to maintain the critical and transferrable foundations and applications of Creative Thinking. Most notably that to effectively engage in creative thinking an individual must be able to generate, reflect, and iterate on ideas while maintaining a balance of usefulness and novelty.

Our Creative Thinking Learning and Assessment Model (*see Figure 1*) is designed to capitalize on the foundational understanding developed through the previous work in this area and to build upon insights gained through their application and assessment. The framing for our model is unique in that it moves beyond both conceptual constructs and assessment frameworks to include concepts related to both *learning* and assessment. In application this allows for more emphasis to be placed on the evaluative, metacognitive, and communicative processes involved with the creative thinking processes, their cultivation, and the benefits that they may provide in improving specific creative thinking outcomes.

This broader conceptualization allows for the inclusion of aspects of creative thinking that are more difficult to access in large scale summative assessment environments, but may be relevant and attainable for the development of learning solutions as well as summative and formative classroom assessments and tools.

Our Creative Thinking Learning and Assessment Model defines creative thinking as *The capacity to expand beyond conventional boundaries to create unconventional and valuable solutions.* The domain is divided into five creative thinking facets that support the skills and processes required for effective creative thinking across contexts, audiences, and domains.

Figure 1 Creative Thinking Learning and Assessment Model

The Creative Thinking Learning and Assessment Model facets are outlined as follows:

- **Explore**
  - ***Description:*** The Explore skill is focused on gaining an understanding of the conventions within a domain and/or challenge. The Explore skill focuses on

identifying, understanding, and evaluating the important components of the variables, features, and boundaries around what is considered conventional for both the domain and the challenge. The intent is that this information is important for understanding the factors for determining what is considered unconventional but also valuable, in that the ideation process is leading toward a novel, viable, and useful product (e.g., unique idea, solution, prototype, artifact, etc.).
    - ***Outcomes***: The identification of conventional features, variables, and boundaries for a domain and/or challenge.
- **Create**
    - ***Description:*** The Create skill is focused on *creating* new unconventional ideas based on an understanding of what is common or conventional. This skill also focuses on understanding degrees of unconventionality and how ideation for unconventionality might be influenced and limited by what society and the individual consider to be conventional. Additional focus is placed here on operating within the constraints of what we consider to be valuable in that this ideation process is leading to a novel, viable, and useful product (e.g., unique idea, solution, prototype, artefact, etc.).
    - ***Outcomes***: The creation of multiple unique solutions, prototypes, and artifacts for a domain and/or challenge.
- **Evaluate**
    - ***Description***: The Evaluation skill is used in conjunction with other creative thinking skills throughout the creative thinking process as we seek to both determine what is considered conventional, unconventional, and valuable and also understand what is *influencing* that determination. The focus of the Evaluation skill is to understand the uniqueness and usefulness of products of ideation and creation in relation to not only other products, but also in the context of both societal and personal constructions of what is considered conventional, unconventional, and valuable. This includes the understanding of personal factors including personal biases and limitations in knowledge and experience.
    - ***Outcomes:*** Understanding of the feasibility, viability, effectiveness and value of the solution, ideas, or artifacts generated in the create phase.
- **Improve**
    - ***Description***: The Improve skill is focused on further ideation to improve existing ideas and create an optimized solution for the challenge. This skill utilizes the understanding of what is conventionality and unconventionality and valuable generated through the other creative thinking skills as a foundation to revisit and improve existing ideas to create an optimized solution or solutions for the challenge. There is an additional focus here placed on constraints and how they might be influencing, informing, and limiting creative possibilities.
    - ***Outcomes***: The creation an optimized solution or solutions for the challenge
- **Communicate**
    - ***Description***: Creative Thinking *in the context of a domain* also includes an additional skill: Creative Communication. For creative thinking to be *applied* it is more than just the thought that counts. Creative communication facilitates the representation and sharing of creative ideas using visuals (e.g., showing instead of telling) and text for the purposes of collaboration or application. The focus is on effectively impacting the reception and understanding of

messages across a wide range of audiences by making information relatable and accessible.
- ***Outcome:*** The creation of optimized communication solutions that make information relatable and accessible across a wide range of audiences

Task-specific considerations for the Creative Thinking Learning and Assessment Model requires tasks that dive more deeply into the metacognitive process and communicative applications of creative thinking. Designing tasks to make the otherwise implicit processes involved with metacognition more explicitly have required the creation of new item types and scenarios designed to make those implicit processes explicit not only for assessment purposes, but also for the benefit of improving those processes for the learner.

To explore the learning and assessment of creative thinking we have developed multiple units of task-based scenarios to elicit the engagement of students in the creative thinking processes and measure their demonstration of abilities with those skills and competencies. The purpose of the samples units are to illustrate the conceptual ideas of the framework, ensure that those ideas are functional with the target population, and to validate the core ideas for the units and item-types.

As part of the development process for the samples we conducted cognitive interviews, otherwise known as cognitive labs. A cognitive lab is a method of studying the mental processes one uses when completing a task such as problem solving, creative writing or drawing.

Cognitive labs are generally conducted earlier in the test development process and complement quantitative data generated by validation studies and field tests; they do not produce large amounts of statistical data but they do allow for in-depth and qualitative exploration of concepts and items.

The purpose of the cognitive labs was to present the framework samples to students who represent the target testing population in order to evaluate how the students perceive and perform in the tasks and whether the stimuli elicit the competencies that the Frameworks purport to measure. The findings of the cognitive labs will be used to inform the next versions of the assessment units and further refinement of the creative thinking model.

Methods

Participants

A total of 11 students participated in this cognitive labs during July to August 2018. Among these 55 % female (n = 11; 6 females). Participants were between the ages of 14 and 16. The sample was mainly recruited through a network of ACT employees.

Materials

The creative thinking cognitive labs included a prototype unit: '*List it!'*. The unit is designed to include task types being explored to measure four of the five proposed creative thinking learning and assessment model facets: Explore, Create, Improve, and Evaluate. Each unit contains multiple tasks, each task is designed to measure a single creative thinking facet. Table 1 provides the number of students experienced each unit organized by creative thinking domain.

In ‘List it!' students are given a series of tasks to score points in a game to accumulate points. Throughout the game students are asked to both generate ideas for points, but also to evaluate their own responses and responses of others to better understand what influences the degree to which those answers are conventional or unconventional. This unit consists of 7 tasks, each one is designed to measure a single facet of creative thinking skills.

Task 1 is an activity aligned with the Explore facet and is designed to assess students’ abilities to identify conventional ideas. Task 2 is aligned with the Evaluate facet and is designed to assess students’ abilities to evaluate degrees of conventionality in the context of what they consider to potentially be a more common or a less common example. Task 3 is aligned with the Evaluate facet and is designed to assess students’ abilities to evaluate and understand their own perceptions and reasoning for what constitutes conventionality. Task 4 builds on the previous task and is aligned with the Create facet. This task is designed to assess students’ abilities to create *un*conventional ideas. Task 5 is aligned with the Evaluate facet and is designed to assess students’ abilities to evaluate degrees of *un*conventionality in the context of what they consider to potentially be a more common or a less common example. Task 6 is aligned with the Evaluate facet and is designed to assess students’ abilities to evaluate and understand their own perceptions and reasoning for what constitutes *un*conventionality. Finally, task 7 is aligned with the Improve facet and is designed to assess students’ abilities to improve and expand on unconventional responses.

Results

Discussions of unit level insights from the cognitive labs are discussed at the facet-level. Overall, students had positive experiences in this unit and spent approximately 20-25 minutes in this unit. Students were engaged and produced a diverse range of responses with varying levels of quality.

Explore

- Students appeared to enjoy the Explore task and provided great feedback on improvements for the instructions to improve the clarity of the task.
- Students also provided feedback on additional category ideas to consider for the game.
- Students found the number of examples required to be burdensome, stating that they ran out of ideas rather quickly. All students, however, completed the list of 6 required responses.

Evaluate

- Students appeared to enjoy the Evaluation tasks related to ranking examples and completed them with ease. Similar rankings were seen across the students with most variation occurring within the top 50% and bottom 50% of the scale.
- Students found the understanding conventionality and unconventionality tasks to be more challenging to complete. While some common reasoning were seen across students (e.g., personal familiarity with the course, popularity of the course) a wide range of reasoning were given overall.

Create

- Students were more engaged with this task than with task 1, as this task required more divergent thinking.
- Students wanted to spend more time discussing their examples, and rationales for their examples, for this task.

- Students appeared to find the number of examples to be less burdensome than task 1, and again all students were able to complete the full set of 6 category examples.

Improve

- Students found the length of this task to be burdensome, but appeared engaged in the process of generating additional examples based on their reasoning provided in the previous task.
- Students noted that they had provided the same reasoning for more than one option in the previous task, making this task confusing.

Key insights informing task revision were apparent in three primary areas: Clarity of prompts, the role of inter-task dependencies, and the number of required responses per task. Insights are outlined below:

Clarity of prompts

Prompts for items with more complex instructions related to fictitious scoring have been refined for concision and clarity. Students found the prompts for some tasks to be "too long to read" and noted that they "only skimmed the instructions" for some of the tasks. Some students had difficulty with the second 'listing' task due to not thoroughly reading the instructions, and assuming conventional responses, similar to those of the first task, were required, while it was actually *un*conventional responses that were being encouraged.

Inter-task dependencies

Inter-task dependencies proved to be beneficial in some aspects and problematic in others. The responses to some tasks were clearly inspired by, or repeated from, previous tasks, particularly those in which a sample of fictitious examples were given. In the Improve facet task the students were building upon their responses from the previous task in which multiple reasoning descriptions were required. In cases where the same reasoning could be applied in multiple cases students were left with limited opportunities for improvement and expansion for additional categories. In other tasks the inter-task dependencies proved valuable. Some students noted that these dependencies allowed them a better sense of the types of features that were influencing their example ideas.

To limit the borrowing of responses from previous tasks new task variables will be introduced between the tasks to limit the borrowing of responses (e.g., replacing the letter that each example should belong to, or the subject of the category that students are generating examples for). This should allow for students to continue to benefit from the process-related inter-task dependencies.

Number of responses

We have limited the number of responses for tasks requiring a list of multiple category examples to four examples. While students were overall able to complete the number of responses required for the tasks in which lists of category examples were required they noted difficulty generating what they considered to be conventional and unconventional examples for more than four examples. The students noted that examples beyond this took a longer time to come up with. It was apparent that these answers became less relevant or more loosely related to the category for the task beyond the fourth example. The fifth and sixth examples also appeared to require significantly more effort to produce.

We have also limited the number of responses required for Evaluation tasks to allow students more time to invest in their explanations and considerations for reasoning.

Conclusions

As expected, cognitive labs provided preliminary insights on what works and what could be improved in regard to both the creative thinking model and the assessment design of the creative thinking units. User experience with 11 students provided valuable information on students' performance patterns across the innovative assessment tasks and item types being considered for further test development.

Areas of greatest potential for improvement include the refinement of areas that will limit extraneous cognitive demands and allow for greater employment of cognitive efforts to be focused on the creative aspects of the tasks.

Resources

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