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Creativity in education: What educators need to know

John Munro

A paper commissioned by the NSW Department of Education

ABOUT THE AUTHOR

John Munro is Professor of Educational Psychology and Exceptional Learning at The Australian Catholic University, Melbourne campus. He is a trained primary and secondary teacher and a registered psychologist. He has written several recent books including Teaching Oral Language and co-edited Powerful Learning – A Strategy for System Reform.

EDUCATION: FUTURE FRONTIERS

EDUCATION: FUTURE FRONTIERS is an initiative of the NSW Department of Education exploring the implications of developments in AI and automation for education. As part of the Education: Future Frontiers Occasional Paper series, the Department has commissioned essays by distinguished authors to stimulate debate and discussion about AI, education and 21st century skill needs. The views expressed in these essays are solely those of the authors and do not represent the views of the NSW Department of Education.

Creativity and innovation have attracted increasing interest over the last decade as key twenty-first century skills (Binkley et al., 2012). In this paper, John Munro discusses whether creativity is a concept that we can identify and measure and what the creative process looks like. He also introduces the Intuitive Theory of Action, the point at which an individual becomes aware of new possibilities and develops a potential solution.

Munro then examines how we can measure creativity in a variety of ways, from standardised tasks and tests through to self-assessment of creative attributes to the assessment of outcomes intended to show creativity.

The paper puts forward practical ways that schools can implement an integrated approach to the measurement of creativity.

HOW IS CREATIVITY DEFINED?

A range of definitions of creativity have been proposed (for example, Runco, & Jaeger, 2012; Treffinger, 2009). Most refer to the ability to produce an outcome that is both original, unexpected or novel and useful, functional, appropriate, effective or relevant for its purpose. Simonton (2012) described the connection as Creativity = Originality × Appropriateness. Whether the outcome is original or appropriate is decided by reference to particular social, cultural, and historical criteria (Plucker, Beghetto & Dow, 2004). Some definitions include additional criteria such as:

- **Elegance:** how understandable, elegant, polished, finished, aesthetic is it?
- **Integration:** how well does it operate as a 'whole', an outcome that has integration or synthesis?
- **Germinality:** how well does it open up new perspectives or opportunities, generate new creativity?
- **Emotionality:** its capacity to stimulate positive emotions such as surprise or other relevant feelings, the 'wow' factor.
- **Elaboration:** the extent to which it has elaborated or reformulated what was known or done previously.

CREATIVITY IN EDUCATIONAL CURRICULA

Certainly Australian and international curricula believe we can both assess and teach creativity. The Australian Curriculum identifies critical and creative thinking as part of the general capabilities. The critical and creative thinking learning domain identifies four interrelated elements that comprise knowledge here. Each element comprises three components and describes how students develop thinking from Foundation to Year 10:

1. Students inquire, identify, explore and organise information and ideas. They pose or frame up questions that will guide the creative activity; identify and clarify information that is relevant to the enquiry and prioritise their ideas; collect, organise, analyse, compare and combine information.
2. Students generate ideas, possibilities and actions. They imagine possibilities and link ideas; plan a pathway for implementing their creative activity and for solving a problem; generate alternatives; investigate options and trial and evaluate possible solutions.
3. Students reflect on the thinking and processes they used. They describe, analyse and evaluate the thinking strategies they used to find a solution; explain how and why they selected these thinking strategies; describe how they

transferred their knowledge to other contexts and how and why they made the transfer.

4. Students analyse, synthesise and evaluate the reasoning and procedures they used. They identify and analyse the reasoning they used to find and apply possible solutions; plan a pathway for implementing their creative activity and for solving a problem; evaluate the effectiveness of their ideas, products, methods and courses of action.

The Australian Curriculum recommends that these four elements be embedded in the various domains.

Internationally, the OECD values creative and critical thinking to the extent that it will include their assessment in the Programme for International Student Assessment (PISA) from 2021, in addition to reading, mathematics and science (Vincent-Lancrin, 2017). An initial rubric to guide the development of assessment tasks is currently being trialed in several countries. It comprises the aspects shown in Table 1.

As you can see, the Australian and international approaches provide an essentially similar perspective on creativity and innovation that is consistent with the definitions. Both see it as the act of generating an outcome that is novel and judged to be functional or useful. The outcome can be a tangible product or a process such as a way of thinking or a set of ideas. If we as educators are to foster creativity, we need to recognise creative outcomes. The act comprises both creative and critical activity; a creative outcome requires both the generation of novel ideas and their analysis and evaluation.

Both the Australian Curriculum and the OECD approaches imply that the act is not restricted to particular domains such as the creative arts, music, poetry or creative literature. It can be applied to all domains, including mathematics, economics and history. Both approaches see creativity in terms of ways of thinking processes. This thinking transforms a person's knowledge in particular ways. It leads to an outcome that meets the criteria for being creative.

Table 1: A rubric to guide the development of OECD assessment tasks

	Creativity **Generating novel ideas and solutions**	**Critical thinking** **Questioning and evaluating ideas and solutions**
Enquire	Feel, empathise, observe, describe relevant experience and information Explore, seek and generate ideas	Understand the context/frame and boundaries of the problem Challenge assumptions, check accuracy, analyse gaps in knowledge
Imagine	Make connections, integrate other disciplinary perspectives stretch and play with unusual/risky/radical ideas	Identify strengths and weaknesses of evidence, arguments and claims
Do/share	Produce, perform or envision something that is personally novel	Appraise/base/justify opinion/products on logical, ethical or aesthetic criteria/reasoning
Reflect	Assess the novelty of solutions and possible consequences	Acknowledge uncertainty/limits of chosen solution/position

Taken from Vincent-Lancrin (2017).

THE DISTINCTION BETWEEN CREATIVE THINKING AND CREATIVE OUTCOMES IS IMPORTANT FOR HOW WE THINK ABOUT CREATIVITY IN EDUCATION AND HOW WE MEASURE IT.

The distinction between creative thinking and creative outcomes is important for how we think about creativity in education and how we measure it. It assumes that we can distinguish between the capacity to generate creative outcomes and the actual creation of them. The generative capacity is referred to as 'creative potential' and the outcomes as creative products or 'artifacts'.

The distinction assists us to unpack what we mean by creativity in education. Both the definitions and the curricula provide explicit criteria for determining the extent to which an outcome is judged to be creative. Criteria for measuring the capacity of individuals to engage in the creative process can be derived from unpacking this activity. The following section examines the creative process in more depth.

WHAT DOES THE CREATIVE PROCESS LOOK LIKE?

The knowledge trajectory of a creative idea

Most of us are familiar with examples of creativity in science and technology, for example that James Watt created the steam condenser that improved steam engines or that Marie Curie developed the theory of radioactivity. The historical accounts of how these and many other creators responded to challenges or solved problems show a range of common features in the emergence of a creative outcome. First, their creative outcomes were a response to a challenging issue at the time.

Second, they defined the issue in terms of a particular problem or specific enquiry or question that guided the investigation. The skill to explicate or unpack what was often a broad issue into a specific focused enquiry is a key aspect of being creative. They were also prepared to modify their question or redirect their enquiry as they tested it. Others in their culture at the time would have been aware of the issue but did not respond to it in this way.

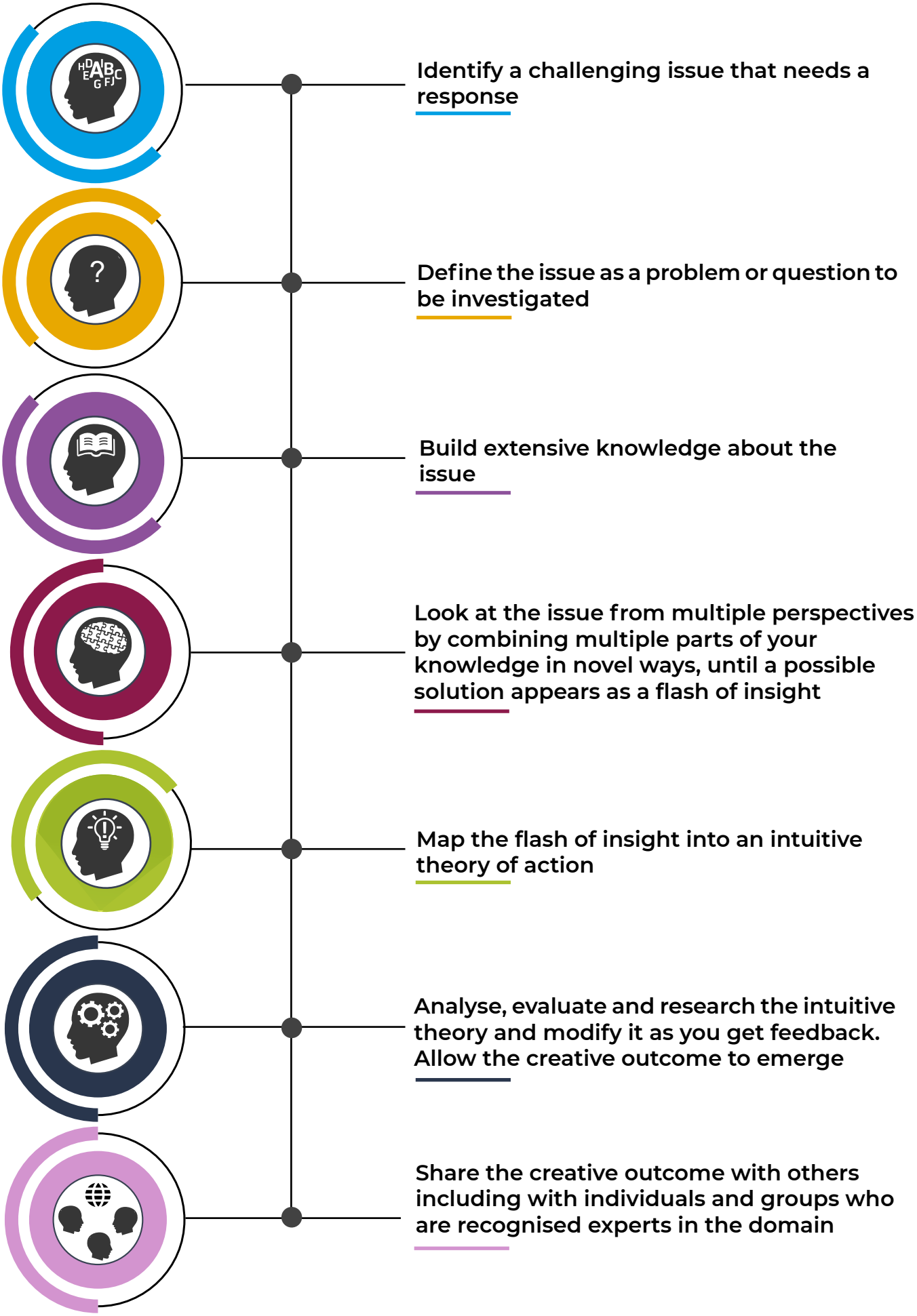
Third, they built an extensive knowledge about the issue. Many formed an expert understanding of the issue as they researched it.

Fourth, they looked at the issue in novel ways. This often involved linking their interpretation of the problem or issue with other aspects of their knowledge. They thought divergently and inferred possibilities. They scanned what they knew and spontaneously generated new, unique links. This process has been called 'making fluid analogies' or 'far transfer'. The individual applies what they know about an apparently unrelated topic to the issue at hand. Interestingly, they often reported forming a visual image of these links (Simon, 2001). James Watt, for example, recalled experimenting with steam from his mother's boiling kettle.

Many of the creators described how they became aware of a potential solution. It appeared as an image, or a flash of insight. There are four aspects of these visualisation experiences that led to creative outcomes:

- They appeared as a visualised image, often described as being 'in the mind's eye'. They were well-defined and could easily be remembered and used.

DIAGRAM: THE KNOWLEDGE TRAJECTORY OF A CREATIVE IDEA



- They appeared suddenly and instantly in a completed, whole structure, rather than being built up bit by bit.
- They were unique and personal to the individual, deriving from the individual's earlier personal experiences of their world.
- They often appeared suddenly at unexpected times, when the creator was engaged in activities unrelated to the task and disengaged from thinking consciously about the topic. During these times they have often allowed ideas to 'run wild' in their minds.

Fifth, they mapped their 'flash of insight' into an 'intuitive theory of action' (or ITA) about a possible solution. Their theory was intuitive because it described what they believed might be possible based on their knowledge of the topic at hand. It included their speculations or possible options. At the point of its generation the theory hadn't been tested or evaluated. It was a theory of action because it was in a form that allowed it to be researched or investigated. Some were less able to describe their theory sufficiently well in language and expressed it in visual forms and art, concrete and mechanical models and demonstrations (Simon, 2001).

Sixth, they analysed, researched and extensively evaluated their intuitive theories and interpretations. This allowed them to map their intuitive theory into an objective theory about a phenomenon or a solution to a problem that had empirical validity and support. The creator needed to collect evidence to test the intuitive theory. They did this in a range of ways, including in scientific experiments, by generating a product and trying it out or by collecting the responses of relevant others. A key question examined by the creator was: How well does the intuitive theory explain the phenomenon or solve the problem?

During this phase the creator may have modified their initial creation repeatedly to respond to the ongoing outcomes of the experimentation or evaluation. They needed to know how to implement the evaluation. They also needed to share their theory with other members of the community and to respond to and use evaluation and feedback.

Seventh, the novel objective theory and the outcomes and products that derived from it were communicated more broadly, investigated within the community and are judged in terms of their relevance and effectiveness. The creator needed to know how to engage in this communication and to help others see the relevance and value of their creation. This may have required the ability to persuade others of the need for their creation and of its value.

These seven steps have scaffolded and underpinned the emergence of creative ideas, and their associated outcomes and products, for the most notable creators. This knowledge trajectory also has implications for how we identify and assess creativity in the classroom. Each phase delivers particular knowledge outcomes, and when educators know to look for these, they are more able to recognise instances of creativity and to respond formatively to them.

HOW DO WE GET THESE OUTCOMES?

This seven-phase trajectory can be aligned with two approaches that describe creativity; the stages models and the separate factors models. Both have relevance for identifying and assessing creativity in education. The trajectory shows the phases of knowledge reported by the creators. It has been described in creativity research by the 'stages models' that conceptualise creativity as comprising a number of stages. In 1926, Graham Wallas proposed a four stage model. An individual

detects new information (the Information stage), thinks about it (Incubation), generates a novel interpretation (Illumination) and tests it (Verification). This model has been modified over the decades and continues to inform research. This paper draws on Cropley and Cropley's (2012) stages model that is described in a later section.

The trajectory also identifies key factors that influence each phase. The second type of model identifies the separate factors implicated in creativity. Rhodes (1961) proposed four factors in his 'Four P's framework':

- The creative person: this refers to the capacities of the creator or actor and includes their creative potential.
- The creative process: this refers to the activity in which the individual engages to generate the creative outcome and includes their motivation, learning, thinking, and communication skill.
- The creative press: this is the relationship between the creative individual and the environment and cultures in which they interact during the entire creative activity. It includes the extent to which the culture supports the creative activity, scaffolds it and provides feedback.
- The creative product: this is the outcome of the creative activity.

The Four P's framework has been extended in various ways. For example, Simonton (1990) recommended that it include the ability to convince others of one's creative work – that is, creative persuasion. In his Five A's framework, Glăveanu (2013) describes creativity as an event in which an actor (the creator) interacts in particular ways (that are referenced on thinking creatively) with issues or objects in their culture to generate an outcome (an artifact) that is judged by others (the audience) to be creative. Each issue or object has specific functions, uses or purposes that determine how it can be used – its 'affordances'.

This way of looking at creativity modifies the Four P's framework in two main ways. First, it differentiates the creative press into two parts: the audience, who interact with and respond to the creative activity at all phases of the creative trajectory and the focus or 'object' of the creative activity, that has particular functions of uses. It extends the Four P's framework to the Five A's framework; the five aspects of actors, actions, artifacts, audiences, and affordances.

Second, it perceives the five aspects interacting during the creative process. This focus on the interaction is important in that it is 'bi-directional' or reciprocal. The creative outcome is a consequence of the integrated networked or synergistic activity.

Both types of models have relevance for identifying and assessing creativity in the classroom, particularly when they are synthesised. Progress through the various stages requires a range of personal capacities including the ability to think strategically and purposefully, conative influences (personality and motivational aspects) and emotional-affective factors.

At each stage in the creative process the creator uses their personal capacities to interact with their environment and culture. The context can either foster and scaffold or restrict the development of creative outcome. The focus on the environmental interactions during the creative activity can assist educators to examine the extent to which their classroom culture and climate, as well as their pedagogy, scaffold and support creative activity.

This distinction between the audience and the object of the creative activity in the Five A's framework is important in the classroom. The ways in which students interact with the audience in

their environment or culture are different from how they interact with the object or focus of the creative activity. Imagine a Year 4 student thinking creatively about living on the Moon. The information they have about living on the Moon will shape their understanding at any time in different ways from the feedback they get from significant others in their culture. Both types of interaction are necessary.

THE INTUITIVE THEORY OF ACTION

This paper proposes that an essential aspect in the knowledge change trajectory for creativity involves the development of the intuitive theory of action (ITA). This is the point at which the individual becomes aware of new possibilities, or possible options for a solution. As noted earlier, it begins with the flash of insight, when the individual links or associates previously separate ideas and sees, in this synthesis, a possible solution. The flash of insight is the point at which a possible solution becomes apparent.

Prior to this phase, the individual forms an extensive knowledge of the phenomenon or issue. Through reflection, thinking inferentially or divergently, they link this knowledge with other knowledge. They combine two or more areas of knowledge into a broader understanding of the topic. In an earlier section I called this process 'fluid analogising' or 'making far transfer'. This is a key part of the process – the flash of insight does not occur randomly, but is the result of extensive information gathering and deep thinking.

We noted earlier how the flash of insight is formed initially as an image or visualisation. It is then restructured as an intuitive theory of action about the possible solution or outcome. The idea or theory at this point is intuitive because it hasn't yet been tested. It contains both facts and possibilities. These are synthesised and specify actions the individual can take to test the theory.

The four P's of creativity			The five A's of creativity
FOCUS ON			**FOCUS ON**
Internal attributes of the person	PERSON	ACTOR	Personal attributes in relation to a societal context
Primary cognitive mechanisms	PROCESS	ACTION	Coordinated psychological and behavioural manifestation
Feature of products or consensus around them	PRODUCT	ARTIFACT	Cultural context of artifact production and evaluation
The social as an external set of variables conditioning creativity	PRESS	AUDIENCE AFFORDANCE	The interdedependence between creators and a social and material world

Figure 1. Comparing the four P's and the five A's as frameworks. From Glăveanu (2013), 71.

Wallas (Sadler-Smith, 2015) provides a valuable description of this process. He distinguished between three types of awareness or consciousness during cognitive activity:

1. Thinking activity of which the individual is not consciously aware; 'unconscious thinking' or cognitive incubation (Sio & Ormerod, 2009).
2. Thinking that is largely intuitive and in a wholistic imagery form (fringe consciousness).
3. Thinking that is conscious and that permits the active manipulation of ideas.

He proposed that the ITA begins in unconscious thinking, enters awareness in a holistic imagery or intuitive form in 'fringe conscious thinking' and is then converted to a testable theory of action through analytic conscious thinking. Wallas quotes one creator describing the transition from unconscious to fringe awareness as: "I often know that the solution is coming, though I don't know what the solution will be" (Sadler-Smith, 2015, p. 97).

The flash of insight has been described as the 'aha' or 'eureka' moment in the creative process. It does not materialise out of nothing but is the culmination of much intellectual work. As well, it is important to note that although it is possible to support the generation of creative thoughts, it is not possible to guarantee that they will emerge. While knowledge and application of thinking skills are important, creative ideas are also influenced by the individuals involved and the context in which they operate (Beghetto, 2019).

Research has examined the emergence of the 'eureka' moment. During problem solving in the mathematics classroom, for example, it is characterised by both cognitive and emotional features (the dissociation theory of affective/cognitive duality). Stoppel and Czarnocha (2017) question the affective-cognitive balance in the process and in particular the extent to which it is primarily emotional. This is important given the extent to which learning in domains such as mathematics is seen as objective and rational, with little valuing of the expression of emotion during learning.

The flash of insight has been linked with particular brain patterns. More creative individuals allocate their cognitive attention in diffuse ways and take account of a broader range of environmental stimuli than those individuals who are less creative and who focus their attention on a more narrow range of stimuli (Folley & Park, 2005; Friedman & Förster, 2005; Rowe et al., 2007). Their creative thinking draws more on right hemispheric association areas used in semantic processing (Stringaris et al., 2006).

Problems such as anagrams can be solved in multiple ways. Two alternative strategies are: (1) the systematic, analytic and sequential analysis of the problem and possible solutions and (2) the sudden insightful awareness of the solution in a more holistic way. Kounios et al. (2008) examined the relationship between the resting-state brain activity of adults and the problem solving strategy they used. Some researchers believe these resting-state brain patterns are relatively stable over time (for example, Damoiseaux et al., 2006). Those participants more likely to use insight strategies over the systematic search strategies showed a higher level of right over left hemisphere activity than their systematic sequential thinkers, particularly in the lateral association areas when they were 'resting cognitively'.

These research findings suggest that the development of ITAs require particular types of brain activities. They also assist in unpacking creative potential in terms of brain activity. For creative outcomes, the classroom needs to scaffold and encourage the flash of insight, unconscious thinking, intuitive and holistic thinking, and the

linking of emotions with cognition. It needs to provide the opportunity for creative thinkers to explicate, rationalise and evaluate their ITAs.

The formation of ITAs in the classroom

From a measurement perspective, can we see evidence that students form ITAs about classroom teaching? Consider the following scenario.

A Year 8 class was learning about how the human body digests food. The teacher described the journey of a hamburger, through the buccal cavity, the oesophagus, stomach and into the intestine. The teacher mentioned that the gastric juices in stomach, including hydrochloric acid, break down protein foods such as meat, eggs and milk.

The teacher asked: "Did anyone think of questions about this that I haven't mentioned?" One student, Gina, asked: "How do the glands in the wall of the stomach know how much acid to squirt out?" The teacher asked: "Why do you ask this question?"

Gina explained: "You said that too much acid could cause ulcers. Not enough wouldn't break down all the food. If I ate a hamburger today and a salad yesterday, my stomach would need different amounts of hydrochloric acid. I don't think I have ulcers in my stomach and so somehow my body controls it. Do my eyes somehow work out how much acid I would need for food I will eat? Can you tell somehow by chewing the food? Do you have detectors in your stomach to tell you?" This was Gina's ITA about the teaching.

Gina interpreted the teaching information differently from her peers. They generally converted the teaching information to an essentially literal understanding. Gina went much further. She identified a problem or an issue and defined the issue in terms of a specific enquiry or question. She looked at the issue in a way that was not typical for her cohort. Her interpretation showed evidence of inferences and possibilities that none of her class peers, exposed to the same teaching, formed spontaneously. She inferred that digestion is a set of chemical reactions that need to be controlled and that this happens by managing or controlling the amount of each chemical. She synthesised these into a 'big idea' or model about digestion. Her ITA extended the teaching. It included both known facts and possibilities about digestion. It was intuitive at the time because Gina hadn't tested or evaluated it. It was in a form that allowed it to be researched or investigated. It was unique to Gina; her peers were initially surprised by her interpretation of the information.

Interestingly, both Gina and two peers independently researched her ITA on the internet after the class and reported their interpretations in the next science lesson. Although her peers did not spontaneously form her ITA during the first lesson, they were sufficiently interested in and motivated by her possibilities to pursue them.

Forming the ITA requires multiple ways of thinking

Gina's unique interpretation of the teaching suggested the spontaneous use of a range of thinking strategies. She formed inferences and synthesised them to form the possibility that the uncontrolled release of digestive juices could damage an individual's stomach. This typified divergent thinking. As well, she analysed and evaluated her inferences and the links between them. This allowed her to check that her emerging interpretation was comprehensible. This is typical of convergent thinking.

The creative process involves both the generation of novel ideas and interpretations and also their analysis and evaluation, in response to a particular problem, issue or challenge. Framing the problem or issue, comprehending the relevant information, forming the ITA, its analysis, modification and communication can all include the generation of

new ideas. Each is analysed and evaluated in terms of the convergent outcome.

The two processes operate in each stage of the creativity trajectory in a balanced way. The analysis and evaluation component is influenced both by the creator and through the interactions they have with their environment. The generation and analysis-evaluation processes have been described as the divergent-exploratory and convergent-integrated modes respectively in the creative process (Barbot, Besançon, & I Lubart, 2011). The measurement of creativity needs to take account of both.

TYPES OF CREATIVITY?

The characteristics of each individual ITA, and therefore the quality and impact of their creative outcomes, differ. The creation of a Guernica or a Theory of Relativity requires knowledge, thinking, emotional and a range of other personal characteristics, as well as social and cultural support, usually not available to children. This has led some researchers to propose that children and adolescents are unlikely to be creative.

I have already indicated my belief that children and adolescents can be creative. This is evidenced by child prodigies in domains such as literature (Minou Drouet), art (Pablo Picasso), mathematics (Carl Gauss), chess (Judit Polgar) and astronomy (Tanishq Abraham). These are usually children aged younger than 10 years who have achieved an eminent level of proficiency in a domain (Feldman & Morelock, 2011).

It is also evidenced in the activity of children in the course of everyday living and in how they interact with information in the classroom. Gina's activity, I believe, is an instance of this. Another example is a 4 year old, in their play with toys, who develops a novel way of overcoming an obstacle that their peers could also use to confront the obstacle without receiving prior teaching or help from others. Their outcomes met the criteria of novelty or originality and functionality or use mentioned in the OECD rubric described earlier by engaging the thinking specified in the Critical and Creative Thinking learning domain.

What I am proposing here is the possibility of multiple levels of sophistication in creativity. This is consistent with the identification initially of two types or levels of creativity, 'Big-c' and 'Little-c' that were further differentiated into the Four C Model of Creativity (Kaufman & Beghetto 2009):

1. **Big-c:** these outcomes change in substantial ways how a culture knows, thinks, feels and lives. They lead to paradigm changes in a domain such as science, music, art or literature. They allow a culture to progress. They require high levels of expertise, high creative thinking, particular personality and emotional dispositions and institutional and cultural opportunities.
2. **Little-c**: these outcomes lead to smaller, novel changes in everyday contexts. It requires domain knowledge and skills, the ability to use creative processes and thinking skills, task motivation and environmental opportunities, creative attitudes and dispositions such as unconventionality, inquisitiveness and imagination, and the ability to display or share the creative outcomes.
3. **Mini-c**: these are outcomes that lead to creative changes in how an individual acts or what the individual knows; they don't necessarily lead to changes in how others operate. It can draw on a more restricted domain knowledge and skills. Mini-c outcomes may not be obvious in the classroom unless teachers know what mini-c creativity looks like and provide opportunities for it to emerge.
4. **Pro-c:** this refers to creative outcomes that lie between Little-c and Big-c in their impact or influence on a domain, institution or culture.

These outcomes change practices and thinking in a field in various ways. They include outcomes that extend and transform current practices to create new products, knowledge or practices within an existing domain. Pro-c requires an expert understanding of the field or domain and the ability to reflect on it and to evaluate, analyse and weigh up the ideas.

The Four C Model offers a framework for conceptualising and classifying the levels of creative expression and provides a potential path or trajectory of creative maturation. A young creator might show Mini-c in their play, or even Little-c if given appropriate environmental scaffolding and encouragement. By developing extensive expertise and focusing on field-wide issues and ideas, they may move onto the stage of Pro-c in specific domains. They may ultimately achieve a Big-c contribution to the field. However, Kaufman and Beghetto (2009) suggest that it is not necessary that Big-c creators need to pass through the other categories to become an eminent creator.

The four types involve the creators forming ITAs that are based on understanding the context and involve possibilities and options that question and extend individuals' current knowledge. The ITAs differ in the breadth of knowledge to which they apply and complexity of thinking on which they draw. Mini-c creativity usually involves creative thinking about a personal issue in one's immediate context. It has a limited impact and can deliver an outcome in a comparatively short time. Big-c creativity involves creative thinking about generally accepted ideas and practices in one's culture. It has a much broader impact and usually takes a much longer time to deliver an outcome. The identification and measurement procedures can take account of these factors.

THE FOUR TYPES INVOLVE THE CREATORS FORMING INTUITIVE THEORIES OF ACTION THAT ARE BASED ON UNDERSTANDING THE CONTEXT AND INVOLVE POSSIBILITIES AND OPTIONS THAT QUESTION AND EXTEND INDIVIDUALS' CURRENT KNOWLEDGE.

CREATIVE POTENTIAL

The synthesis of the capacities an individual needs to generate a creative outcome is referred to as their 'creative potential'. This includes cognitive factors such as the ability to think strategically and purposefully, various non-cognitive conative influences (personality and motivational aspects) and emotional-affective factors. In this paper creative potential comprises the capacities discussed below. It is supported by the componential models of creativity (Amibile, 1996; Urban, 2002).

The capacity to generate creative outcomes requires, firstly, knowledge and skills in the specific focus of the creativity. The individual needs a good understanding of the topic, relative to their level, and the ability to think about it automatically. 'Relative to their level' is key. Gina, for example, had a good understanding of digestion for a Year 8 student.

The individual also needs to believe that their knowledge can be enhanced. They can use this knowledge to analyse, evaluate, and elaborate information. Gina believed that there was more to know about how the stomach breaks down food.

Whether creativity is restricted to particular domains or is a more broadly based phenomenon continues to be debated (Kaufman & Baer, 2004). Some aspects of one's creative potential may be domain

Table 2. The creativity criteria, the types of tasks used to assess each, and the scoring protocol

Creativity criterion	The task used to assess it	How it is scored
Fluency	Produce a large number of ideas in words, figural images or actions	Critical thinking, questioning and evaluating ideas and solutions
Flexibility	Think creatively and divergently, generate a range of ideas by making novel links, shift between domains, analyse, evaluate and synthesise	Number of categories of relevant responses
Originality	Generate uncommon or unique ideas that are less obvious or expected	The originality/novelty of the responses
Elaboration	Develop, embellish or elaborate ideas	Amount of detail in the responses
Usefulness	Generate ideas that are practical and relevant	The relevance of the responses
Abstractness	Sense the essence of a problem or an issue, its level of abstraction	Level of abstraction
Resistance to premature closure	Keep an open mind, work with unanswered questions from multiple perspectives	Level of engagement with unanswered questions, unresolved issues

specific while others can be applied across domains (Urban, 2002).

Secondly, would-be creators need the ability to think creatively about the ideas. This includes the ability to think divergently, and to analyse and evaluate. They need to frame up specific problems or challenges in a situation, to infer from the content and to link to other areas of knowledge. They generate novel ideas from a range of categories and synthesise them into an ITA. As well they need to manage, direct, monitor and regulate their creative activity. Together these comprise an individual's capacity to be creative: their creative potential.

Over the past seven decades over 250 tasks and tests have been developed to assess aspects of individuals' creative potential. These include the Torrance Tests of Creative Thinking (TTCT) (Torrance, 1999) and the Evaluation of Potential Creativity (EPoC) (2009), both of whicht assess a range of creative thinking skills in the verbal and figural domains. The Test of Creative Thinking (TCT-DP) (Urban & Jellen, 1996) assesses creativity through drawing. Table 2 shows the attributes usually assessed, the types of tasks used, and the scoring protocol.

Creative potential also requires the ability to direct and manage one's general thinking for creativity, to retain relevant knowledge in memory, plan the thinking pathway, use the most appropriate thinking at any time, monitor progress, and modify one's thinking as the activity proceeds, and show autonomy in one's thinking. This is not usually assessed in isolated, separate tasks, but should be examined in the measurement of the creative process (outlined on the following page).

It also requires the ability to understand the nature of creativity and being creative. Creators should be open to new ideas, be willing to take risks and

understand that creative ideas have their own trajectories. They also need to be committed, focused and intrinsically motivated to bring the idea to fruition.

The conative aspects of creativity are usually measured using rating scales and inventories. Respondents comment either on aspects of their lives that indicate creativity and how frequently they engage in creative activities (biographical inventories) on how they believe they operate in problem solving contexts (creative thinking self-beliefs) or on the extent to which adjectives associated with creativity describe them. Some scales ask respondents to judge how well they display the personality traits linked with creativity, based on their earlier experiences or how they might solve problems. Alternatively, their teachers, parents or peers may be asked to comment on the behaviours they display that may be interpreted as indicative of creativity.

These tools have some key limitations. First, self-reports are subjective, with possible bias and social desirability influences. Second, each tool only measures partial or isolated aspects of creativity. These limitations should be taken into account when deciding how best to measure creative potential.

MEASUREMENT OF THE CREATIVE PROCESS

We noted earlier that the creative process proceeds through a number of phases of knowledge change described by the stages models. The model used here is a modification of Cropley and Cropley's (2012) stages model shown in Table 3. It uses their names for each stage with Sadler-Smith's recommended modification to Wallas' model shown in brackets. Intimation is located between Incubation and Illumination because individuals need to think divergently about the ideas before they can form possibilities. These three stages probably overlap in activity.

Measurement of the creative process focuses on what the individual knows and does about implementing the creative process. It involves collecting data about the outcome of each stage. Activity here comes from the individual's creative potential (their ways of thinking, motivational style and personality features) interacting with the audience and the affordance. The synthesis of these delivers the outcome for the stage (Cropley & Urban, 2000). If an outcome is not available, the creative process will either cease or be redirected, possibly to an earlier stage.

Outcomes at the intimation and illumination stages provide evidence of the flash of insight, the student's ability to reflect and the fluid analogy links they make. Measurement at the incubation stage shows evidence of divergent thinking and openness to developing the novel interpretation. Measurement of metacognitive processes used manage and steer the creative activity can be included.

This paper proposes that this sequence of knowledge change underpins the four types of creativity noted earlier. We are familiar with it for Big-c creativity. Young children engaging in Mini-c or Little-c creativity move through the same sequence more rapidly for a much narrower domain of knowledge. Extended open-ended investigative projects and complex problem solving tasks that require students to generate creative, innovative or unusual solutions or outcomes can be used to assess the creativity process. These types of tasks predict the later creative achievements of artists (Getzels & Csikszentmihalyi, 1976).

Examples include the DISCOVER tasks (Maker, 2006) and Sternberg's (2006, 2009) diffuse social problem solving tasks. Students are provided with open-ended or ill-structured problems and require the ability and willingness to frame up, or problem-find, and plan a solution. My recommendations for constructing and implementing the problems and for scoring the solving activity in terms of its creativity are described elsewhere (Munro, 2015).

Cropley and Cropley's stages model	
Stage	**Measures the extent to which individuals:**
Preparation	Identify a problem or challenge (problem finding), clarify and define it
Activation (information)	Learn, collate and organise the relevant domain knowledge
Generation (incubation)	Generate divergent and novel, intuitive interpretations of the problem; they infer, analyse and make new links
Generation (intimation)	Show evidence of active 'wondering' and searching for possibilities through self reflection
Illumination	Are aware of a novel possibility or a solution from which they form an ITA
Verification	Analyse, evaluate and refine/modify the ITA and convert it to an initial outcome
Communication	Share the outcome with others and use feedback to evaluate and modify it
Validation	Respond to judgments of the relevance and effectiveness of the creative outcome

Each student's activity can be assessed in terms of a number of problem solving skills used in an integrated way. These provide a set of criteria you can use to evaluate a student's solution attempts. These examine the student's ability to:

1. Define the problem or issue
2. Identify possible solutions
3. Develop a possible solution pathway
4. Decide what they might need to know and do to solve the problem, with whom they might need to collaborate
5. Decide barriers that could restrict their solution activity and how they could overcome these obstacles
6. Decide how their problem solving activity could affect others and influence the community in which it was done and how they might 'bring the community' with them
7. Decide how they could monitor the effectiveness of their problem solving activity.

Each criterion is assessed in terms of the number of separate ideas mentioned (the fluency) and the extent of divergent thinking displayed. This scoring also provides an indication of a student's creative engagement, their creative self-efficacy, their metacognition as a creator, their intrinsic motivation and their ability to communicate their solution. The seven criteria can be applied more generally to instances of Mini-c or Little-c creativity in the classroom. Educators look for instances and if possible, record them visually or at least ask students to recount how they progressed through the activity.

MEASUREMENT OF THE CREATIVE CULTURE

This is the context or environment in which the creative activity occurs. The interaction between creative individuals and their cultures is critical for all aspects of the creative process. It influences, for example, a person's motivation to engage in the activity, which, in turn, affects creativity (Said-Metwali et al., 2017). The nature of this interaction changes as the creative process progresses. It includes access to phenomena in one's culture that stimulate and scaffold the curiosity or interest of the creator and that provide information about it.

There also needs to be cultural support to pursue the creative activity. This includes the environment valuing new ideas and providing the opportunity for the creator to display high intrinsic motivation and drive to pursue novel ideas. The culture should also provide both the opportunity for the creator to communicate their creative work and feedback about it.

The classroom is an important culture for the student creator. An issue for measurement here is the extent to which the classroom permits creative activity. ITAs are necessary for the generation of creative outcomes. In the creative knowledge trajectory, they mediate between an individual's creative potential and whether they actually generate creative outcomes. Students can have the potential but not realise it in outcomes. Classroom cultural support for creativity will be indicated in teachers' responses to ITAs.

The features of ITAs often disconcert teachers. Their intuitive nature means they may contain inaccuracies or errors. The ITAs include possibilities that the student has not yet tested. When given the opportunity to reflect on or field-test them, they operate as creators and either validate, modify or reject them. Teachers may want to correct inaccuracies, rather than allow their students to investigate the ITAs.

Furthermore, ITAs are personal and subjective; they are not formed only from the teaching and contain extra ideas. Teachers may see them lacking objectivity. There may have an element of uncertainty about them and may require students to entertain unanswered questions or ambiguities.

Teachers can identify examples of creative thinking when they know what these look like and when they provide the opportunity for the ITAs to be shared. The classroom culture can either foster or restrict their emergence.

One issue for the measurement of creativity is the extent to which the classroom provides explicit opportunities for the ITAs to emerge. Educators and schools can develop indicators of a classroom climate that is likely to support the development of ITAs and evaluate the extent to which teaching typically supports them. They can examine, for example, the extent to which the classroom culture affords students the opportunity to:

- 'Incubate' and 'illuminate' ideas and to use the three types of thinking noted by Wallis. To what extent does a classroom foster the 'flash of insight'? Does it provide time for personal reflection or time to play with ideas?
- Express the emotions associated with creative activity, to be curious, think intuitively and to imagine.
- Form and show their ITAs and provide time for this.
- Reflect on how their ITAs can solve social problems (Sternberg, 2009). Students are guided to 'read' their cultures and link their ITAs with them.
- Link their understanding with what others know and value and how to communicate their novel ideas and 'bring along the audience', that is, 'creative persuasion'.

Systematic reviews of the characteristics of classroom cultures that foster creative learning is provided by Davies, Jindal-Snape, Collier, Digby, Hay & Howe (2013) and de Souza (2000). They note the importance of classroom cultures that, firstly, provide the opportunity for students to play with ideas in self-directed ways, have choice in what and how they learn, to learn collaboratively and outside of the school. Secondly, that focus on students' strengths and interests, accept multiple interpretations of a topic and involve non-prescriptive planning, and thirdly that build respectful student-teacher relationships and enhance student self-confidence.

Classroom cultures that inhibit creativity provide limited opportunities for students to engage with content in a personal way. Matching findings have been reported for the work environment. Hunter, Beddel and Mumford (2007), in a meta-analysis, noted that creativity correlated with challenge, intellectual stimulation, and positive social interactions.

The extent to which classroom cultures foster creative learning has been measured through student and teacher perceptions of classroom practice and through observations of it. For example, the Classroom Activities Questionnaire (CAQ) (Cicchelli, 1989) identifies aspects of classroom practice that facilitate creative thinking skills. These include encouraging students to build on strong content knowledge through discussion and adding their own ideas, valuing thinking skills and deep learning, and fostering a climate characterised by divergence, humour and openness. The CAQ continues to be used in education and research, for example in Armfield's (2007) evaluation of learning and teaching in an innovative middle school program. Research suggests that classrooms that foster an open climate and higher-level thinking have higher creativity scores (Houtz and Denmark, 1983).

MEASUREMENT OF THE AFFORDANCES

As well as interacting with people in their environments, creators also interact with significant objects in their environment. These objects are a focus of their activity throughout the creativity process. They shape how a person thinks about them and how they interact with them. An object does this through how it is and what it offers – its affordances.

For example, a person sees a cup and identifies it as a means for drinking liquids. They have learnt this from their culture. They may not see it as a means of transferring heat, as a candle holder, as a location for a herb garden, as a goal for ping pong basketball or as a bird feeder. The affordances that you see an object offering determine how you relate to it. The Five A's framework (Glăveanu, 2013) proposes affordances as one of the factors in the creativity process.

Different people can interpret the same set of affordances differently, based on what they know and how they think and act. Creators respond to the affordances of a real-world item in innovative ways. They may discover new affordances and even create some. In other words, an object can be used in a range of ways, from conventional to highly innovative.

Tasks that assess the thinking linked with understanding affordances are the Multiple Uses and Alternative Uses tasks. Future tasks could monitor changes in how an individual relates with an object as they progress along the creative trajectory and the range of ways in which they interact with it.

This paper assumes that an analysis of the creative process is incomplete without the interaction between the actor and the affordances. This impacts on the creative process and the emerging outcome.

MEASUREMENT OF THE CREATIVE PRODUCTS

Measurement of the creative qualities of products has been recommended as a data source (Amable 1982; Kaufmann and Baer, 2012) because they come closest to 'real world' creative production. The product can be examined from two perspectives: the final outcome and the gradually emerging outcome. The main focus on measurement here is on the final outcome, although the criteria used for the assessment often involve making inferences about the creator's thinking and conative attributes as they developed it.

The Consensual Assessment Technique

The Consensual Assessment Technique (CAT) involves the measurement of outcomes. Individuals produce creative outcomes in domains, such as art, music, science, maths or literature. The tasks are open ended to allow more originality and flexibility in outcomes and to dependence on domain specific skills.

These are rated by experts in the domain who share a set of subjective standards for creativity in that domain and can recognise and judge creativity in it (Baer, Kaufmann and Gentile, 2004). Judges can, potentially, assess a product from both subjective and objective perspectives.

The outcome can be a tangible product or object, a process such as a way of thinking or a set of ideas such as a theory. They can be compared on various criteria, for example, their extent of originality, unexpectedness or novelty; or their usefulness, practicality, value, functionality, appropriateness, effectiveness or relevance for its purpose. Depending on the domain, additional criteria might include:

- Elegance: how polished, finished, aesthetic they are.
- Integration: how well each operates as an integrated 'whole'.
- Germinality: how well each opens new perspectives or options for further creativity.
- Emotionality: how well each stimulates positive emotions such as surprise or other relevant feelings, the 'wow' factor.
- Elaboration: the extent to which each has elaborated or reformulated what was known or done previously.

The CAT has been used in schools to judge products in content areas such as art, literatures, science and technology (Cropley, 2000) and used by teachers to evaluate their students' products score. For example, writing samples from eighth graders that included poems, fiction and personal narratives were rated for creativity by a panel of experts (Baer, Kaufmann & Gentile, 2004). High inter-rater reliability between the judges supports the use of CAT in school contexts.

Creative outcomes in the classroom

Outcomes in various classroom domains can be assessed in terms of their creative qualities (Kaufman & Baer, 2006). Students can show creativity in a range of contexts. These include:

Creative storytelling ability

Students generate and write creative poetry or stories in various contexts, for example, given a title, part of a story or more pictures. With many young children, the creativity is shown in play scenarios that include story telling. Their outcomes can be assessed in terms of:

- **Novelty or originality:** the extent to which the story developed is unusual and atypical of children of that age.
- **Complexity:** the extent to which the plot and form of the story shows sophistication and complexity in its organisation of ideas that is atypical of children of that age.
- **Emotionality:** the extent to which the story communicates emotion and takes account of and engages its audience.
- **Task appropriateness:** how well the stories meet the specified criteria.

Creative artwork

Sternberg and Grigorenko, (2007) used the creative collage task. Children were given a set of plastic stickers and selected a topic from the list: Silliness, Happiness, My Home, or My Dream. They made a creative collage to match their topic, using the stickers. The outcomes were rated on abstractness, symmetry, originality, novel use of materials, likeability, craft and expressiveness, task appropriateness, and complexity.

Creative problem solving in STEM

Open-ended 'big' problems can be formed from topics taught and students are encouraged to generate creative solutions. The topic of photosynthesis is frequently taught in the middle years. Photosynthesis is the process by which plants, in their leaves, convert carbon dioxide to oxygen. Students can investigate the challenge: How might the rate of photosynthesis be increased? They can speculate about the influence of variables such as the shape or size of the leaves, the temperature of the leaves, the type or intensity of light hitting each leaf.

Creative thinking in reading

Grigorenko, Jarvin, Tan and Sternberg (2008) used reading comprehension to identify creative thinking. Students from grades 7–12 read fiction and non-fiction that differed in difficulty. Each had accompanying analytic (or traditional) comprehension tasks that assessed readers' ability to recall information or to analyse the content of the reading passage and creative tasks that assessed five levels of proficiency:

- To elaborate or slightly modify the ideas in the text
- To change in novel ways the ideas in the text, including its theme or context
- To respond in creative ways to changes in the text
- To provide additional creative information for a text, for example, suggest a creative beginning or extension to a text
- To create novel variations to a text, for example, protagonists or narrative lines

The creative items discriminated better for higher achievers while the traditional items discriminated between average learners.

Creativity in productions and performances

Outcomes on applied curriculum topics, open-ended performances, productions and practical achievements in domains both in and outside of school can be assessed for evidence of creativity. Domains include music, dance, art, sports, technology or engineering.

The outcomes can show evidence of creative thinking and learning in practical domains and personality and conative characteristics such as intrinsic motivation, drive, commitment and perseverance. Rubrics can be used to evaluate them. These examine evidence of the student's:

- understanding of the domain, the breadth and depth of knowledge underpinning the outcome
- ability to think divergently and creatively, see implications and possibilities, analyse and evaluate, compare, apply and synthesise

- ability to monitor and self-regulate their progress to the outcomes, how they planned and implement their activity, how they monitored, reviewed and modified their on-going activity
- skills in pursuing, selecting, organising and using the relevant information, how they dealt with challenges that arose
- intrinsic academic motivation, task commitment and focus
- ability to engage collaboratively when necessary
- attitudes and social skills, for example, attitudes toward cultural diversity, scientific attitudes, and interviewing individuals and groups

Portfolio assessment

Teachers and students can collect samples of students' outcomes over a relatively longer duration and assess them in terms of their creative quality. The portfolio may contain outcomes such as written and spoken information (essays, computer programs) art and sculpture pieces, constructions and other products, experiment journals, and videotaped recordings of outcomes in the visual and performing arts, dance, drama/theatre, technology, science and maths areas. Rubrics can be designed to provide a set of criteria along which are complex products can be assessed in terms of the creativity expressed.

Students can also be encouraged to retain multiple drafts or progressive versions of the development of the product to illustrate their thought processes, their self-assessment of their trajectory and the developing sophistication of the product. Modern technology allows them to record the emerging product. Again, scoring rubrics can be used to provide evidence of the emerging outcome.

How to describe the quality of a student's ITA?

The student's ITA is the earliest form of the outcome. Its possibilities and options provide its creative features. The quality of an ITA is indicated by its semantic complexity. The Structure of the Observed Learning Outcomes (SOLO) Taxonomy (Biggs & Collis, 1982) and the Dynamic Skill Theory (Fischer, 2008) provide taxonomies for assessing this. Each evaluates a student's understanding following exposure to teaching in terms of the complexity of the ideas taught. Higher levels of complexity are associated with higher academic outcomes (Chan, Tsui, Chan & Hong, 2002).

These taxonomies can be used to form assessment protocols to evaluate the quality of the intuitive theories. These protocols would indicate the extent to which students extend and elaborate the teaching information through inference, analysis and evaluation, and synthesise intuitive theories about it. They can assess the number of ideas that comprise the student's interpretation (the fluency of the ITA), the number and types of semantic relationships inferred subjectively by the students, the hierarchical organisation of the constituent concepts, and the inference of 'big' ideas.

The protocol I use to assess students' responses is shown in Table 4. It refers to the criteria used to evaluate the number and types of inferences and syntheses evident in a student's response. The criteria are arranged in order of increasing complexity. Measurement of the quality of the ITAs provides information about students' ability to create outcomes that is not readily available otherwise.

Table 4 : Criteria for assessing the complexity of a student's interpretation	
Increasing complexity ↓	1. Did it link the ideas only in ways that match the teaching?
	2. Did it infer spontaneously one additional idea, attribute or link?
	3. Did it infer two or more single additional ideas, attributes or links?
	4. Did it synthesise several (or all) of the inferred examples or attributes into a pattern?
	5. Did it link the inferred pattern with matching patterns in other contexts; far transfer?
	6. Did it link two or more inferred patterns into trends, infer how one pattern might affect other patterns?
	7. Did it identify what several trends share or how they affect each other; generalise the patterns?
	8. Did it form a theory that draws together or integrates the abstract systems?

Table 5: Their application to Gina's ITA	
How do the glands in the wall of the stomach know how much acid to squirt out?	**Level 8:** this indicates the intuitive theory if the other ideas are consistent with it and support it.
You said that too much acid could cause ulcers.	**Level 1:** linked ideas in a way that matched the teaching
If I ate a ... need different amounts of hydrochloric acid.	**Level 4:** inferred link between the proteins in foods and therefore how much acid they need.
I don't think I have ulcers in my stomach and so somehow my body controls it.	**Level 5:** inferred that the release process must be controlled like other processes in her body.
Do my eyes ... food I will eat? Can you tell ... chewing the food? Do you have detectors in your stomach to tell you?	**Level 6:** inferred possible trends

A SYNTHESISED PERSPECTIVE ON CREATIVITY

This paper describes the measurement of creativity in terms of the Five A's framework. The five aspects of actor, action, artifact, audience, and affordance interact dynamically in a synergistic, networked way to lead to creative outcomes. We noted earlier five main reasons for measuring creativity. For any of these purposes, assessing only one of these aspects is likely to lead to less effective decision making than drawing on multiple aspects. You would expect, for example, that assessing the application of a sequence of thinking skills would be more indicative of overall creative ability than assessing each matching individual skill separately.

This paper suggests that schools and educational institutions can develop an explicit protocol that collects and synthesises data from as many of the sources as possible. The protocol needs to recognise that creativity is domain specific and culturally specific. It is a multidimensional creativity concept; creative achievement draws on a range of factors and its measurement needs to be based on several sources. Interpretation made of the data collected at any time needs to reflect the aspect/s of the Five A's model that were actually measured. The measurement of divergent thinking is not a measurement of creativity but of one component of creative potential. In summary, the measurement of creativity needs to talk authentically about individuals in their culture, not about specific skills, attitudes or emotions.

REFERENCES

de Acedo Lizarraga, M. L. S., & de Acedo Baquedano, M. T. S. (2013). How creative potential is related to metacognition. *European Journal of Education and Psychology, 6*(2), 69-81.

Amabile, T. M. (1982). Social psychology of creativity: A consensual assessment technique. *Journal of personality and social psychology 43*(5), 997. http://dx.doi.org/10.1037/0022-3514.43.5.997

Amabile, T. M. (1996). *Creativity in context*. Westview Press.

Armfield, S. W. (2007). *A descriptive case study of teaching and learning in an innovative middle school program* [Unpublished EdD thesis]. Northern Arizona University.

Baer, J., Kaufman, J. C., & Gentile, C. A. (2004). Extension of the consensual assessment technique to nonparallel creative products. *Creativity research journal, 16*(1), 113-117. https://doi.org/10.1207/s15326934crj1601_11

Barbot, B., Besançon, M., & I Lubart, T. (2011). Assessing creativity in the classroom. *The Open Education Journal*, *4*(1), 124-132.

Beghetto, R. A. (2006). Creative self-efficacy: Correlates in middle and secondary students. *Creativity Research Journal, 18*(4), 447-457.

Beghetto, R. A. & Kaufman, J. C. (2014). Classroom contexts for creativity. *High Ability Studies, 25*(1), 53-69. https://doi.org/10.1080/13598139.2014.905247

Beghetto, R. A. (2020, May). On creative thinking in education: eight questions, eight answers. *Future EDge, 1,* 48-71. https://education.nsw.gov.au/teaching-and-learning/education-for-a-changing-world/future-edge/future-edge-issue-1

Biggs, J., & Collis, K. (1989). Towards a model of school-based curriculum development and assessment using the SOLO taxonomy. Australian journal of education, 33(2), 151-163.

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first century skills. In E. Care, P. Griffin & M. Wilson (Eds.), *Assessment and teaching of 21st century skills* (pp. 17-66). Springer.

Byrd, R. E. (1986). *Creativity and risk-taking.* Pfeiffer International Publishers.

Carson, S. H., Peterson, J. B., & Higgins, D. M. (2005). Reliability, validity, and factor structure of the creative achievement questionnaire. *Creativity Research Journal*, *17*(1), 37-50. https://doi.org/10.1207/s15326934crj1701_4

Center for Creative Learning (2015). Assessing Creativity Index. http://www.creativelearning.com/free-resources/assessing-creativity-index

Chan, C. C., Tsui, M. S., Chan, M. Y., & Hong, J. H. (2002). Applying the structure of the observed learning outcomes (SOLO) taxonomy on student's learning outcomes: An empirical study. *Assessment & Evaluation in Higher Education*, *27*(6), 511-527. https://doi.org/10.1080/0260293022000020282

Cicchelli T. (1989). The Class Activities Questionnaire (CAQ). In P. J. Keyser & R. C. Sweetland (Eds.), *Test Critiques* (Vol. 7, pp. 110-18). Test Corporation of America.

Cropley, A.J. (2000). Defining and measuring creativity: Are creativity tests worth using? *Roeper Review*, *23*(2), 72-79.

Cropley, D., & Cropley, A. (2012). A psychological taxonomy of organizational innovation: Resolving the paradoxes. *Creativity Research Journal, 24*(1), 29-40.

Cropley, A. J., & Urban, K. K. (2000). Programs and strategies for nurturing creativity. In K. A. Heller, F. J. Mönks, R. Subotnik & R. J. Sternberg (Eds.). *International handbook of giftedness and talent* (pp. 485-498). Elsevier.

Csikszentmihalyi, M. (1999). Implications of a systems perspective for the study of creativity. In R. Sternberg (Ed.), *Handbook of creativity* (pp. 313–335). Cambridge University Press.

Damoiseaux, J. S., Rombouts, S. A. R. B., Barkhof, F., Scheltens, P., Stam, C. J., Smith, S. M., & Beckmann, C. F. (2006). Consistent resting-state networks across healthy subjects. *Proceedings of the national academy of sciences*, *103*(37), 13848-13853. https://doi.org/10.1073/pnas.0601417103.

Davies, D., Jindal-Snape, D., Collier, C., Digby, R., Hay, P., & Howe, A. (2013). Creative learning environments in education – A systematic literature review. *Thinking skills and creativity, 8*, 80-91. http://dx.doi.org/10.1016/j.tsc.2012.07.004

Domino, G. (1994). Assessment of creativity using the ACL: A comparison of four scales. *Creativity Research Journal*, *7*, 21-23.

Feldman, D. H. and Morelock, M. J. (2011). Prodigies. In M. A. Runco & S. R. Pritzker (Eds.). *Encyclopedia of Creativity* (2nd ed., pp. 261–265). Academic Press. https://doi.org/10.1016/B978-0-12-375038-9.00182-5

Fischer, K. (2008). Dynamic cycles of cognitive and brain development: measuring growth in mind, brain, and education. In A. M. Battro & K. W. Fischer (Eds.). *The Educated Brain* (pp. 127-150). Cambridge University Press.

Folley, B. S., & Park, S. (2005). Verbal creativity and schizotypal personality in relation to prefrontal hemispheric laterality: a behavioral and near-infrared optical imaging study. *Schizophrenia research*, *80*(2-3), 271-282. https://doi.org/10.1016/j.schres.2005.06.016

Friedman, R. S., & Förster, J. (2005). Effects of motivational cues on perceptual asymmetry: Implications for creativity and analytical problem solving. *Journal of personality and social psychology, 88*(2), 263. https://doi.org/10.1037/0022-3514.88.2.263

Geake, J. G. (2007). High abilities at fluid analogising: A cognitive neuroscience construct of giftedness. *Roeper Review, 30*, 187-195.

Getzels, J. W., & Csikszentmihalyi, M. (1976). *The creative vision: A longitudinal study of problem finding in art.* Wiley.

Glăveanu, V. P. (2013). Rewriting the language of creativity: The Five A's framework. *Review of General Psychology*, *17*(1), 69-81.

Gough, H- G., & Heilbrun, A. B. (1983). *The Adjective Check List Manual* (2nd ed.). Consulting Psychologists Press.

Gough, H. G. (1992). Assessment of creative potential in psychology and the development of a creative temperament scale for the CPI. In J. C. Rosen & P. McReynolds (Eds.), *Advances in psychological assessment.* (Vol. 8, pp. 225-257). Plenum.

Grigorenko, E. L., Jarvin, L., Tan, M., & Sternberg, R. J. (2008). Something new in the garden: Assessing creativity in academic domains. *Psychology Science*, *50*(2), 295-307.

Haensly, P. A., and Torrance, E. P. (1990). Assessment of creativity in children and adolescents. In C. R. Reynolds& R. W. Kamphaus (Eds.). *Handbook of Psychological and Educational Assessment of Children: Intelligence and achievement* (pp. 697-722). Guilford Press.

Hocevar, D. (1981). Measurement of creativity: Review and critique. *Journal of Personality Assessment*, *45,* 450-464.

Houtz, J. C., & Krug, D. (1995). Assessment of creativity: Resolving a mid-life crisis. *Educational Psychology Review, 7*(3), 269-300.

Hunter, S. T., Bedell, K. E., & Mumford, M. D. (2007). Climate for creativity: A quantitative review. *Creativity research journal, 19*(1), 69-90.

Kaufman, J. C., & Baer, J. (2012). Beyond new and appropriate: Who decides what is creative? *Creativity Research Journal*, *24*(1), 83-91.

Kaufman, J. C., & Baer, J. (2006). Intelligent testing with Torrance. *Creativity Research Journal, 18*(1), 99-102. https://doi.org/10.1207/s15326934crj1801_11

Kaufman, J. C. and Baer, J. (2004). Sure, I'm creative – but not in mathematics!: self-reported creativity in diverse domains. *Empirical Studies Of The Arts*, *22*(2), 143-155.

Kaufman, J. C. and Beghetto R. A. (2009). Beyond big and little: The Four C Model of Creativity. *Review of General Psychology*, *13* (1), 1–12.

Kaufman, J. C., Beghetto, R. A., & Watson, C. (2016). Creative metacognition and self-ratings of creative performance: A 4-C perspective. *Learning and Individual Differences, 51,* 394-399. https://doi.org/10.1016/j.lindif.2015.05.004

Kaufman, J.C., Plucker, J.A,. Baer , J. (2008). *Essentials of creativity assessment*. Wiley.

Kounios, J., Fleck, J., Green, D. L., Payne, L. Stevenson, J. L., Bowden, E. M. and Jung-Beeman, M. (2008). The Origins of Insight in Resting-State Brain Activity. *Neuropsychologia, 46*(1), 281–291. https://doi.org/10.1016/j.neuropsychologia.2007.07.013

Kumar, V. K., Kemmler, D., & Holman, E. R. (1997). The Creativity Styles Questionnaire-Revised. *Creativity Research Journal*, *10*, 51-58.

Lubart, T.I., Besançon, M., & Barbot, B. (2011). *Evaluation du Potentiel Créatif (EPoC). (Test psychologique et Manuel).* Editions Hogrefe France. (English Version : *Evaluation of creative potential: Test and Manual)*

Lubart, T. I., Zenasni, F., & Barbot, B. (2013). Creative potential and its measurement. *International Journal of Talent Development and Creativity*, *1*(2), 41-51.

Maker, C. J. (2006). *The DISCOVER Project: Improving Assessment and Curriculum for Diverse Gifted Learners.* University of Connecticut: The National Research Center on the Gifted and Talented. https://files.eric.ed.gov/fulltext/ED505483.pdf

Mednick, S. A. (1962). The associative basis of the creative process. *Psychological Review*, *69*, 220-232.

Munro, J. K. (2015). Scenario problem solving: A measure of the quality of gifted students' thinking. *Australasian Journal of Gifted Education*, *24*(1): 23-29.

Plucker, J. A. (1999). Is the proof in the pudding? Reanalyses of Torrance's (1958 to present) longitudinal data. *Creativity Research Journal, 12*(2), 103-114.

Plucker, J. A., Beghetto, R. A., & Dow, G. T. (2004). Why isn't creativity more important to educational psychologists? Potentials, pitfalls, and future directions in creativity research. *Educational psychologist*, *39*(2), 83-96.

Rhodes, M. (1961). An analysis of creativity. *Phi Delta Kappan, 42*, 305–311.

Robinson L. (2019). *Picasso, Guernica*. Khan Academy. https://www.khanacademy.org/humanities/art-1010/early-abstraction/cubism/a/picasso-guernica

Rowe, G., Hirsh, J. B., & Anderson, A. K. (2007). Positive affect increases the breadth of attentional selection. *Proceedings of the National Academy of Sciences, 104*(1), 383-388. doi/10.1073/pnas.0605198104

Runco, M. A. (1987). Interrater agreement on a socially valid measure of students' creativity. *Psychological Reports. 61*, 1009-1010.

Runco, M. A. (2004). Creativity. *Annual Review of Psychology, 55,* 657– 687.

Runco, M. A., & Jaeger, G. J. (2012). The standard definition of creativity. *Creativity Research Journal, 24*(1), 92-96.

Runco, M. A., Plucker, J. A., & Lim, W. (2001). Development and psychometric integrity of a measure of ideational behavior. *Creativity Research Journal, 13*(3-4), 393-400. https://doi.org/10.1207/S15326934CRJ1334_16

Sadler-Smith, E. (2015). Wallas' four-stage model of the creative process: More than meets the eye? *Creativity Research Journal, 27*(4), 342-352.

Said-Metwaly, S., Van den Noortgate, W., & Kyndt, E. (2017). Approaches to measuring creativity: a systematic literature review. *Creativity. Theories – Research-Applications, 4*(2), 238-275.

Simon H. A. (2001) Creativity in the arts and the sciences. *The Kenyon Review, 23*(2), 203-220.

Simonton, D. K. (2012). Taking the US Patent Office criteria seriously: A quantitative three-criterion creativity definition and its implications. *Creativity research journal, 24*(2-3), 97-106.

Simonton, D. K. (1990). History, chemistry, psychology, and genius: An intellectual autobiography of historiometry. In Runco., M. A. & Albert., R. S. (Eds.), *Theories of creativity 5* (pp. 92–115). Sage.

Sio, U. N., & Ormerod, T. C. (2009). Does incubation enhance problem solving? A meta-analytic review. *Psychological bulletin, 135*(1), 94.

de Souza Fleith, D. (2000). Teacher and student perceptions of creativity in the classroom environment. *Roeper Review, 22*(3), 148-153.

Sternberg, R. J. (2006). Practical Giftedness. *Gifted Education International, 21*(1), 89-98.

Sternberg, R. J. (2009). *Academic Intelligence Is Not Enough! WICS: An Expanded Model for Effective Practice in School and Later in Life.* Mosakowski Institute for Public Enterprise. https://commons.clarku.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1004&context=mosakowskiinstitute

Sternberg, R. J., & Grigorenko, E. L. (2007). *Teaching for successful intelligence: To increase student learning and achievement.* Corwin Press.

Sternberg, R. J., Kaufman, J. C., & Pretz, J. E. (2003). A propulsion model of creative leadership. *The Leadership Quarterly, 14*(4-5), 455-473.

Stoppel, H., & Czarnocha, B. (2017). Creativity, Aha! Moments and teaching-research. In G. Kaiser (Ed.), *Proceedings of the 13th International Congress on Mathematical Education* (pp. 689-690). Springer. http://doi.org/10.1007/978-3-319-62597-3_108

Stringaris, A. K., Medford, N., Giora, R., Giampietro, V. C., Brammer, M. J., & David, A. S. (2006). How metaphors influence semantic relatedness judgments: The role of the right frontal cortex. *NeuroImage, 33*(2), 784-793. http://doi:10.1016/j.neuroimage.2006.06.057

Torrance, E. P. (1999). *Torrance Test of Creative Thinking: Norms and technical manual.* Scholastic Testing Services.

Treffinger, D. J. (2009). Myth 5: Creativity is too difficult to measure. *Gifted Child Quarterly, 53*, 245-47.

Treffinger, D. J., Young, G. C., Selby, E. C. , and Shepardson, C. A. (2002). *Assessing creativity: A Guide for educators.* National Research Center on the Gifted and Talented.

Urban, K. K. (2002, August). The general and special case: Development and nurturing of creativity [Keynote address]. 7th Asia-Pacific Conference on Giftedness, Bangkok.

Urban, K. K., & Jellen, H. G. (1996). *Test for Creative Thinking - Drawing Production (TCT-DP).* Swets and Zeitlinger.

Vincent-Lancrin, S. (2017). *Assessing Progression in Creativity and Critical Thinking Skills.* OECD. https://www.slideshare.net/OECDEDU/assessing-progression-in-creativity-and-critical-thinking-skills-by-stphan-vincentlancrin-oecd

Wallach, M. A., & Kogan, N. (1965). *Modes of thinking in young children.* Holt, Rinehart and Winston.

Wallas, G. (1926). *The art of thought.* Harcourt, Brace, Jovanovich.

The Modes of thinking in young children (Wallach & Kogan, 1965) comprises three verbal subtests (Instances, Alternate Uses and Similarities). Alternate Uses asks for as many unusual uses as possible for common items (e.g., newspaper, knife, car tire, button, shoe, key). It is the most widely used subtest and can be scored for fluency, uniqueness flexibility, originality and usefulness (practicality and relevance to reality. It also comprises two subtests consisting of ambiguous figural stimuli (Pattern Meanings, Line Meanings). Versions of these tasks have been used either in isolation or with other tasks on later scales.

The Remote Associates Test (Mednick, 1962) measures creativity by asking individuals to suggest remote associates for stimulus words. The respondent sees three apparently unrelated words (for example, moon, cheese, and grass) and suggests a fourth word that links them (for example, blue).

The Evaluation of Potential for Creativity (EPoC; Barbot, Besançon, & Lubart, 2011) is used with primary school students. It measures two types of creative thinking skills, divergent exploration and convergent synthesis and integration in the verbal and figural domains. It examines developmental trends across school-grade levels.

Composite verbal creativity scores explained approximately 50% of the spread of scores on the criterion of publicly recognized creative achievements 20 years after assessment and predicted about three times as much of the criterion variance as IQ measures. The TTCT scores differentiate well between those who do and don't subsequently achieve public acclaim recognition as creative (Plucker, 1999).