Exploring the Characteristics of Undergraduate Students' Creative Thinking Skills

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Abstract—**This study aims to develop a self-report inventory to measure University students' perception of their creative thinking skills. Creative thinking is a critical learning outcome in higher education and one of the essential 21st Century Competency. The data were collected from 253 students of a university in Hong Kong. A structural equation model was applied to confirm the construct validity of the instrument. The result shows that the key characteristics of creative thinking skills are empirically constructed by creative character, originality, sensitivity, synthesizing and resistance to premature closure. The five characteristics of creative thinking can be considered as learning processes or outcomes to inform the design of instructional events and learning activities to nurture students' creative thinking skills.**

Keywords—**creative thinking, creative thinking skills, higher education**

I. Introduction

As reflected in different university surveys, creative thinking appears to be a common challenge in student learning. A teaching development project was initiated to explore the characteristics of university students' creative thinking. A domain-general self-report inventory was developed for use as one of the assessment tools. Since creative thinking is a generative process [1], the inventory is mainly process-based, with most items describing actual behaviours and a few person-based questions. Creative thinking process can be streamlined enhancing the creative thinking skills. Five characteristics of creative thinking skills were identified from the literature review for developing the inventory. The self-report inventory can be used as a baseline assessment to provide university researchers and practitioners with a description of students' creative thinking skills across disciplines for instructional design.

Creative thinking is deemed an important factor contributing to the success of arts, sciences and business and therefore has long been a focus of educators. Studies in creativity can be traced back to as early as the 1930s [2] and voluminous research, theories and knowledge have been generated since then. In a review of research methodologies between 2003 and 2012, Long identified 612 empirical studies on creativity from five key creativity journals [3]. Definitions of creativity proliferated over the last century. Guilford and Stein define creativity in terms of novelty (or originality) and acceptability (or usefulness) [4, 5]. Torrance argues that many things can be learned creatively and recognizes that creativity is a distinguishing characteristic of outstanding individuals [6]. In a fast-changing, increasingly complex and globalized society, a creative thinker is flexible and capable of coping with unexpected situations and producing innovative and useful solutions. At different educational levels, creativity has been recognized as an important skill or competence that students need. The Partnership for 21st Century Skills included creativity as an essential skill for success and encouraged educators to integrate creativity in teaching core academic subjects [7].

In response to the increasing emphasis on creativity, a Community of Practice (CoP) project was initiated to engage teachers to understand students' creative thinking to develop pedagogies that can enhance students' creative thinking skills and subject knowledge teaching in tandem. Five key characteristics of students' creative thinking were identified from the literature and operationalized as an inventory to examine the construct validity of the instrument. Creative thinking is a multidimensional construct involving a set of different skills [8] and it is commonly agreed that the creativity assessment should be conducted using multiple assessment measures [9]. The inventory was developed to understand students' perceptions of their creative thinking. The inventory is domain-general, allowing it to be used for courses of different disciplines.

II. Literature Review

Despite the complexity and a lack of a single universally agreed-upon definition of creativity, the notion that novelty and usefulness are the two criteria for a work to be called creative is without debate [10]. It was first posited by Stein in 1953 explicitly [2, 5]. Over sixty years, many studies have been done on different fronts, and the conception of creativity has expanded, resulting in the formation of many different conceptual frameworks. One of them is the four P's model of creativity proposed by Rhodes in 1961. Four strands were identified in this model

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to organize the different aspects of creativity: (1) person (the personality, traits or attitudes of a creative person), (2) process (the cognitive learning, thinking or communicating process that converts an idea into a creative object or an articulated form), (3) press (the relationship between human beings and their environment), and (4) products (ideas that are usually expressed in the form of either language or craft) [11]. Thus, creative thinking falls into the process strand of creativity – a generative process that leads to original and useful output.

The first theoretical model of the creative process was proposed by Wallas in 1926 [12]. He divided the process into four stages – preparation, incubation, illumination, and verification. But what key skills underpin the creative thinking process? Scholars have agreed that creative thinking is a multidimensional phenomenon involving a multitude of underlying factors that can be learned [1, 4, 13]. In this study, creative thinking skills are defined as the abilities related to intellectual functioning, cognition processes and the problem-solving underpinning original and useful output, and such abilities can be developed and enhanced. However, there is no commonly agreed framework for such skills to guide the assessment [1]. Through a meta-analysis of the frameworks for creative thinking designed by Ramalingam *et al.* (ACER) [1], Guilford [4, 13], Hokanson [14], The OECD Programme for International Student Assessment (PISA) [15], Torrance [16, 17], and Treffinger *et al.* [18], certain common key skills or characteristics that contribute to the performance of creative thinking were identified. They are related to complex intellectual functioning, cognition and problem solving, such as ideation fluency, flexibility, elaboration, originality, and some personality traits, such as openness to experience.

Creativity assessment generally falls into four categories of measurement: (1) creative products, (2) creative cognition, (3) creative traits, and (4) creative behaviour and achievement [19]. Self-report scales that assess creative achievement include the Creative Behavior Inventory [20, 21], Creative Achievement Questionnaire [22], Creativity Domain Questionnaire [23] and Kaufman Domains of Creativity Scale [24]. For assessing creative traits or self-concepts, self-report scales such as the Gough Personality Scale [25] and the Short Scale of Creative Self [26] are used. Assessment tools available for creative cognition include the Runco Ideational Behavior Scale (RIBS) [27], Creative Attributes and Behavior (SCAB) [28], Cognitive Processes Associated with Creativity Scale (CPAC) [29], Mode Shifting Index [30], and Creative Adaptability Scale [31]. Among the five creative cognition scales, the RIBS, SCAB and CPAC measure a set of creative thinking abilities. The RIBS measures creative ideation, including fluency, originality and combination, while the SCAB measures creative engagement, creative cognitive style, spontaneity, tolerance, and fantasy, and creative idea manipulation, imagery/sensory, flow, metaphorical/analogical thinking, idea generation and incubation are covered by the CPAC measures. However, none of these scales examines elaboration, a key skill commonly identified in the studies reviewed above. RIBS, SCAB, and CPAC self-report scales are driven by divergent thinking. Convergent thinking and divergent thinking are both important factors underpinning creative performance [4, 13–15, 18]. Convergent thinking focuses on idea evaluation and improvement, which helps ensure the quality and usefulness of an idea, whereas divergent thinking concentrates on novelty. There is a need to incorporate a convergent thinking-oriented self-report inventory to measure creative thinking.

The project involves multiple disciplines to test the creative thinking skills across disciplines, and the self-report inventory was designed as domain-general. While some studies argue for the domain-specificity of creativity [32–34], creative thinking is also evidenced as domain-transversal by a fair amount of research [35–38]. For instance, in a qualitative review of creativity training, Scott *et al.* [38] found that cognitive strategies in creative thinking, including underlying core processes such as problem construction, information encoding, combination and reorganization, and idea evaluation were effective in developing creative skills across programmes and domains. We harmonized the above frameworks and identified five key skills and characteristics that can be enhanced across domains through practice, feedback, and diverse applications within teaching and assessment. These key skills and characteristics were used as the subscales to develop the self-report inventory for multiple disciplines.

The key characteristics of creative thinking include creative character, originality, sensitivity, resistance to premature closure and synthesizing. Creative character is the personal beliefs and personalities, including willingness to take risks, tolerance to ambiguity, and self-efficacy that will facilitate creative thinking [13]. A discussion of the creative process often involves a discussion of creative personality. A long list of creative personality traits is identified by voluminous studies [39–42], the ones that appear the most in the frameworks reviewed are incorporated in this scale. The second characteristic, originality, is the ability to generate or extend ideas, claims, and questions that are unique and novel [14–18]. Original thinkers come up with unusual or unique ideas, which is fundamental to the definition of creativity. The third characteristic, sensitivity, is the ability to be aware of problems, defects, changes, signals, and influences [4, 13]; meanwhile emotional sensitivity in the context of social interaction also comes under this category [18]. The fourth characteristic, resistance to premature closure, is the ability to keep open, consider available information, re-examine ideas, and delay closure long enough to make possible original ideas [17]. Although this term was only mentioned explicitly as an assessment criterion in one framework reviewed [17, 43], it is included in our inventory because the idea that delaying closure aids creative performance is supported in multiple studies, e.g., Chirumbolo *et al.* [44] and Guilford [4]. Creative thinkers can stay with a problem and solve it on a higher level of functioning. The fifth characteristic, synthesizing, is the ability to combine or synthesize existing ideas, images, or expertise in original ways to form new ideas or directions [1, 13, 15, 18].

III. Methodology

The creative thinking skills self-report inventory focuses on a person's actual behaviour or preferences that reflect their level of creative thinking skills and characteristics in a general sense. It comprises 5 criteria, 5 items in each criterion, which added up to 25 items in the initial pool. A Likert scale from 1 (strongly agree) to 5 (strongly disagree) was adopted to structure the instrument. A written instruction directed students to consider the statements and decide to what extent they agree or disagree with them in a general sense. An online version of the survey with a consent form explaining the purpose of the project and assuring participants of the confidentiality of the data they provide was distributed to 323 students, including those in control groups. A total of 253 valid responses were received. All respondents participated voluntarily. The average age band of this sample was 20. The samples were then subjected to confirmatory factor analysis using principal axis factoring extraction method and direct oblimin rotation to identify the underlying factor structure of the scale. A cut-off factor loading of 0.30 was used to determine whether an item loads on a given factor [45]. Five factors were extracted with an Eigenvalue greater than 1, accounting for 59% of the variance (see Table I).

Based on item content, the factors were labelled as 1) Creative Character; 2) Resistance to Premature Closure; 3) Originality; 4) Connecting and Synthesizing; and 5) Sensitivity. The factor loadings of the five factors are displayed in Table I. The reliability analysis of the subscales showed Cronbach's alpha of 0.798 for creative character, 0.714 for resistance to premature closure, 0.790 for originality, 0.777 for connecting and synthesizing, and 0.660 for sensitivity.

To evaluate the validity of the five-factor model, the model fit was tested with SEM using several parameters and goodness-of-fit indices, including the Chi-Square test, Standardised Root Mean Square Residual (SRMR), the Root-Mean-Square Error of Approximation (RMSEA), the Comparative Fit Index (CFI), the Tucker Lewis Index (TLI), the Bollen's Incremental Fit Index (IFI), and the Parsimony Goodness of Fit Index (PGFI). The following thresholds were used as guidelines to determine the model fit: RMSEA ≤ 0.08 indicate adequate fit, ≤ 0.05 indicate good fit [46], SRMR ≤ 0.08 indicates good fit [47], CFI, IFI and TLI ≥ 0.90 indicate acceptable fit and ≥ 0.95 indicate good fit [46, 48], and the model is acceptable when PGFI ≥ 0.50 [49]. Given that the chi-square test is highly sensitive to sample size and skewness [50], it was only included for completeness and not as a basis for judging the goodness of fit.

TABLE I. Factor Loadings for Exploratory Factor Analysis of the Pre-test Sample (21 Items)

Factors	1	2	3	4	5
Creative Character (Cronbach's α: 0.798; Eigenvalue: 7.397; Variance explained (%): 35.223)					
1. I enjoy creating unique ideas.	0.839				
2. I like creating unique ideas.	0.746				
3. I work hard to produce original ideas, even though many of them may fail in the end.	0.364				
4. I enjoy coming up with many ways to do things instead of sticking to only one way.	0.356				
5. I like to come up with lots of ways to do things rather than sticking to one way.	0.349				
Resistance to Premature Closure (Cronbach's α: 0.714; Eigenvalue: 1.524; Variance explained (%): 7.258)					
6. Instead of jumping to conclusion, I set aside time to carefully re-examine my mental process (i.e., perception, thinking and reasoning).		0.776			
7. I allow time to carefully reflect on my thinking rather than rushing to conclusion.		0.626			
8. To obtain an effective solution, I allow time to consider available information before choosing the final solution.		0.431			
9. My ideas are often thought-out, with gaps examined and details added.		0.353			
10. I often envision a detailed plan from beginning to end for implementing my ideas.		0.308			
Originality (Cronbach's α: 0.790; Eigenvalue: 1.249; Variance explained (%): 5.946)					
11. I have many unusual ideas.			0.744		
12. Many of my ideas are unusual.			0.730		
13. I often generate new ideas by making unexpected combinations.			0.416		
Synthesizing (Cronbach's α: 0.777; Eigenvalue: 1.173; Variance explained (%): 5.584)					
16. I recognise links among ideas that might seem unrelated.				0.806	
17. I notice connections between ideas that might seem unrelated.				0.538	
18. I form new ideas by synthesizing a number of ideas.				0.495	
19. I am good at spotting the influence of an idea on the situation (e.g., improve or worsen).				0.349	
20. While working on a task, I use different modes of thinking (e.g., thinking in depth about the details and letting my mind wander freely).				0.317	
Sensitivity (Cronbach's α: 0.660; Eigenvalue: 1.082; Variance explained (%): 5.152)					
21 I can discover defects in things easily.					0.687
22. I can spot defects in things easily.					0.612
23. I am better at spotting signals and changes than others (e.g., social signals, changes in the environment, atmosphere, mood, etc.).					0.324

The results showed that all incremental fit indices indicated model misfit while RMSEA, SRMR and PGFI indicated that the model was acceptable, RMSEA = 0.073, SRMR = 0.065, $\chi 2 = 430.231$, df = 184, $p < 0.000$, CFI =

0.871, IFI = 0.873, TLI = 0.853 and PGFI = 0.686. Modification indices suggested a residual covariance between items 1 and 2, items 4 and 5, items 6 and 7, and items 16 and 17 would improve the model. These pairs of items were similar in wording and measuring the same factors. Studies within the SEM show that it is not problematic to allow residual correlations between items with similar wording [51, 52]; therefore, residual covariance was allowed. Subsequent results for the five-factor model showed acceptable to good fit, RMSEA = 0.055, SRMR = 0.055, $\chi 2$= 317.625, df = 180, $p < 0.000$, CFI = 0.928, IFI = 0.929, TLI = 0.916 and PGFI = 0.697 (Fig. 1).

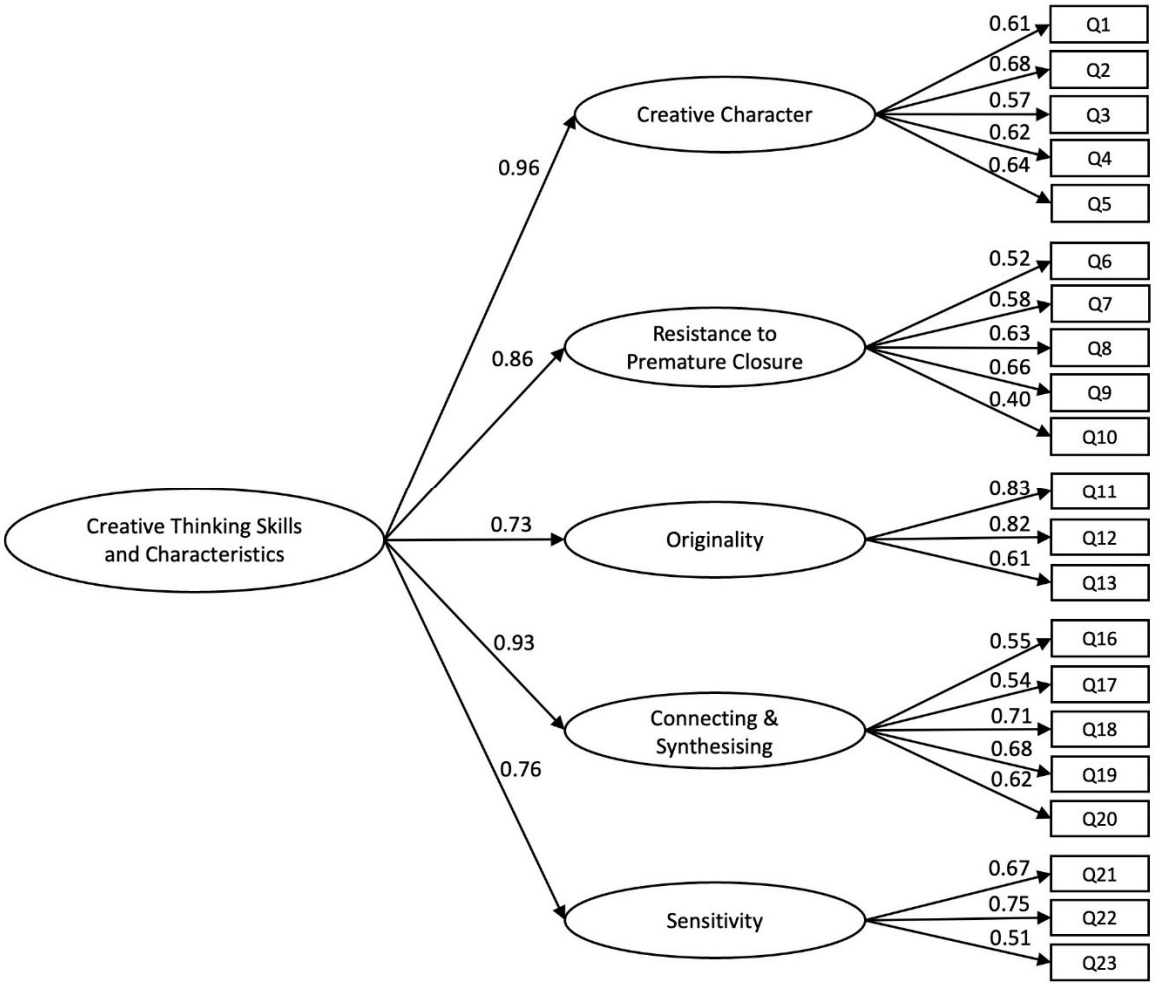

Figure 1. Validated five-factor model for the creative thinking skills self-report inventory.

IV. Discussion

The confirmatory factor analysis yielded a five-factor solution. The items for measuring creative character, resistance to premature closure and synthesizing are kept unchanged, while two items of each construct, originality and sensitivity, were dropped for their factor loadings below 0.03. Students with creative character enjoy creating unique things and working hard to produce original ideas. Even though many of them may fail, they still enjoy exploring different ways to do things instead of sticking to one. The characteristic echoes the definition proposed by Guilford [13] that creative character is a person's personal beliefs and personalities, including willingness to take risks, tolerance to ambiguity, and self-efficacy that facilitate creative thinking. Many studies also reported these characteristics as creative personality traits [39–42].

This study finds that students with the characteristics of resistance to premature closure will set aside time to carefully re-examine their mental process instead of jumping to a conclusion. They consider available information before making the final decision so as to obtain the most effective solution. Their ideas are often thought-out, with gaps examined and details added. They often envision a detailed plan from beginning to end for implementing their ideas. These findings echo [17] definitions that the creative character involves keeping open, considering available information, re-examining ideas, and delaying closure long enough to make possible original ideas. Chirumbolo *et al.* [44] also mentioned that creative thinkers can stay with a problem and solve it on a higher level of functioning; multiple studies support the claim that delaying closure aids creative performance.

Students who are original have many unusual ideas and often generate new ideas by making unexpected

combinations. They come up with unusual or unique ideas, which is fundamental to the definition of creativity. This finding corresponds to the definition provided by Hokanson [14] and Treffinger *et al.* [18] who claim it to be the ability to generate novelty or uniqueness.

Students who are good at making synthesis can recognize links and notice connections among ideas that might seem unrelated. They form new ideas by synthesizing several ideas and are good at discerning the influence of an idea on the situation. While working on a task, they use different modes of thinking. These findings match the definition provided by many studies [1, 13, 15, 18] that it is the ability to combine or synthesize existing ideas, images, or expertise in original ways to form new ideas or directions.

Students with higher level of sensitivity are able to discover defects in things more easily and they notice are subtle signals and changes that others do not. The findings consistent with the definition provided by Guilford [4, 13], who claims that sensitivity is the ability to be aware of problems, defects, changes, signals, and influences.

V. Conclusion

This study developed a self-report inventory that examines the extension of an idea and values convergent thinking. While most of the self-report scales, for example, the RIBS, SCAB, and CPAC, are divergent thinking tests, the study contributes a convergent thinking-oriented instrument to measure creative thinking. Divergent thinking concentrates on novelty, whereas convergent thinking focuses on idea evaluation and improvement, which helps ensure the quality and usefulness of an idea. This self-report instrument, however, has a limitation: the five-factor scale may not fully reflect some key attributes of creative thinking, such as openness to ideas and adaptability. Future studies addressing this issue of coverage can be beneficial. The validity and reliability of the scale can also be further established by sampling a larger group of students. The inventory is a useful domain-general assessment tool for spotting key characteristics of creative thinking. The scale describes creative thinking skills and characteristics which can be informative for developing creative-thinking pedagogies. Further study can be conducted through pre- and post-tests with experimental design to examine the changes in students' level of creative thinking and the effectiveness of creative pedagogies.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Cheung-on Tam is the PI of the project. Cheung-on Tam, Eric Cheng, Anita Chan, and John Rogers are the principal coordinators. All authors conducted the research and edited the article. Eric Cheng supervised data anlaysis. Xueying Tan drafted the paper. All authors have approved the final version.

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