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# Assessing Prospective Science Teachers' Creative Thinking Ability to Solve Environmental Issues at Higher Education

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**Abstract:** *This research work intends to assess the creative thinking abilities of prospective science teachers using a modified form of the essay-type Torrance Test of Creative Thinking (TTCT) named the Tayyaba Creative Thinking Ability Test (TCAT). This test measured four key indicators of creativity: Fluency, Flexibility, Originality, and Elaboration. A purposive sampling technique was adopted, and a sample of 20 students completed the test, and their responses were evaluated using a 5-point rubric. Descriptive statistics revealed that students performed strongest in Originality (mean = 3.85) and Fluency (mean = 3.75), while Flexibility (mean = 3.15) emerged as the weakest indicator. Inferential statistics, including correlation analysis, demonstrated strong positive relationships between Fluency and Originality ($r = 0.72$, $p < 0.01$) and Originality and Elaboration ($r = 0.70$, $p < 0.01$), highlighting the interconnected nature of these skills. Validity was established through the expert's opinion, and reliability analyses indicated acceptable internal consistency (Cronbach's $\alpha = 0.78$). The findings suggest that while students excel in generating innovative ideas, they struggle with adopting diverse perspectives. The findings reveal that while prospective science teachers excel in generating innovative ideas (Originality) and producing multiple solutions (Fluency), they face significant challenges in adopting diverse perspectives (Flexibility). This gap suggests a need for targeted educational interventions to enhance perspective-shifting skills, which are critical for addressing complex environmental issues. The strong correlations between Fluency, Originality, and Elaboration further emphasize the interconnectedness of these creative thinking dimensions, suggesting that fostering one skill may positively influence others.*

**Key Words:** Creative Thinking Ability, Environmental Sciences and Creativity, Torrance Test of Creative Thinking (TTCT)

## Introduction

Creative thinking ability is one of the major goals of science education. As a school, college and university graduates who have good creative thinking abilities will contribute positively to the well-being of the personal, social, technological and economic status of their country and the world as well (Diawati, 2017). However, sufficient practical steps have not been taken so far for the development and incorporation of creative thinking ability, particularly in the domain of science subjects such as chemistry, biology, physics and environmental sciences. Creative thinking ability is an art to master, yet it is difficult to define and measure (Foster & Schleicher, 2022). Literature has shown that there are several social scientists who have developed different tests over time to measure the creative thinking ability of different grades and ages of students, subjects and fields (Sak & Ayas, 2013; Alacapinar, 2013; Ayas & Sak, 2014; Pizzingrilli et al., 2015; Huang et al., 2021). Ulger (2016) reported that creative thinking ability is linked with the thinking process. For this reason, the term "Divergent thinking" was specifically invented by Guilford to define creative

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thinking ability (Dorfman & Gassimova, 2017). Many social scientists used divergent thinking tests to estimate the creative thinking potential of students around the world (Baer, 2011; de Vries & Lubart, 2019). These tests are also called creative thinking ability tests (Hong & Milgram, 2010; Hong et al., 2013). Furthermore, it is inferred from the literature that researchers have developed two types of creative thinking ability measurement tests. The first test is for the creative thinking ability measuring in the general domain, and the second is in measuring the specific domain (Hong & Milgram, 2010; Hong et al., 2013).

The instrument used widely for the measurement of divergent thinking assessed the ideational fluency (a person is proposed to generate all possible uses for a familiar situation or object; it is also called the survival process) of the person was developed by Torrance in 1974, and 1999. Researchers explain that in measuring general domain creative thinking, the respondent is presented with the different and complicated types of problems which they usually do not face in everyday life, e.g. respondents were asked to name as many uses as they can for the newspaper (ideational fluency measure) (Sternberg, 2009; Huang et al., 2017). However, general domain creative thinking ability tests are for only general real-life problem solving but not for specific science-oriented domain real-life problems such as chemistry, biology, physics and environmental sciences (Montag-Smit & Maertz Jr, 2017).

Therefore, measurements designed to assess specific domain creative thinking have been developed to evaluate the creative thinking ability of the student in specific field, this may help the respondents to acquire ability for real life problem solving and utilize their skill in variety of specific domain real life situations (Hong & Milgram, 2010; Long & Plucker, 2015; Lee & Tan, 2025).

Hence, in this present study researcher need a specific domain creative thinking ability test in order to assess prospective science teachers' creative thinking ability in solving environmental sciences related issues.

## Literature Review

### Creative Thinking Ability

Creative thinking ability is one of the most important 21st-century skills (Dilekçi & Karatay, 2023). It is also considered an essential life skill which can be incorporated into the young generation effectively through the education system (Saravanakumar, 2020). Since it is a gateway to potential solutions to several political, economic, and social problems. Creative thinking ability enables students to propose new ideas with different perspectives to solve real-world problems based on their content knowledge (Prajapati et al., 2017).

The learning process becomes more meaningful and enjoyable when problem-solving is led by the creative thinking ability of a person, as it is needed to bring innovation to human life (Khoiriyah & Husamah, 2018). In today's world, the world importance of creative thinking ability is inevitable for everyone to be able to foster new and smooth ideas, review problems from several perspectives and come up with unique and original ideas (Sihaloho et al., 2017). In the twenty-first century, education is a primary source of developing creative thinking ability in students so that they can lead their lives sustainably in the future and can significantly deal with everyday tasks (Orakci, 2023). Creative thinking ability can only be developed through divergent thinking practice (Acar & Runco, 2019). Several researchers around the world reported a strong link between creative thinking ability and problem-solving individuals, which becomes the ultimate achievement of a student to master the art of thoughtfulness of the problem, coming up with various solutions with innovative perspectives (Barutcu, 2017; Yayuk & As' ari, 2020; Elvianasti & Dharma, 2021; Permata et al., 2022).

Researchers define creative thinking ability as a skill to develop, find, or create new constructions of solutions based on data, information or elements that already exist, with a different perspective that appears as a manifestation of their perceived problems, so as to produce a useful solution (Lawson, 1993; Al-Suleiman, 2009; Probowati et al., 2020; Nurwidodo et al., 2024). Therefore, creative thinking ability is considered the most essential in life, and it must be fostered through education (Shen & Lai, 2014).

It is inferred from previous research that creative thinking ability is influenced by several factors, including the respondent's previous and present circumstances, collaborative work and how much the

respondent is motivated to solve the problems (Cheng, 2010; Deng et al., 2016; Jankowska & Karwowski, 2019; Jaenudin, 2023). The majority of research work around the world suggests that students' achievement and creative thinking abilities are different when it comes to classroom environment manipulation (Alkathiri et al., 2018; Starko, 2021; Rahayuningsih et al., 2023).

## Assessment of Creative Thinking Skills

Over the years, many researchers have developed creative thinking ability tests, divergent thinking tests, and creative thinking ability measurement or assessment tests. The term divergent thinking was invented by Guilford; he claimed that potential creative things are originally possible when the respondent has the ability to do divergent thinking in the problem-solving process (Hong & Milgram, 2010; Hong et al., 2013). Later on, one of the most widely used and reliable tests was developed by Torrence; that test is known as the Torrance Creative Thinking Test (TCTT), which has become a standard for assessing the ability of creative thinking (Diawati et al., 2017). Torrance Creative Thinking Test (TCTT) is comprised of figural and verbal criteria; it is a time-consuming test (Bart et al., 2017). Over the years, the standard Torrance Creative Thinking Test (TCTT) has gone through several modifications and adaptations according to the requirements of the research (Sener et al., 2015). Likewise, Torrance, Wu, and Ando created the Torrance Form Demonstration Test (D-TCTT) in 1980; it was less time-consuming. This successful modification led other researchers to develop Abbreviated Torrence Test Adults (ATTA) (Shen & Lai, 2014). With the passage of time, few scientists have modified and designed the Torrence test for the specific domain of the creative thinking ability test (Alabbasi et al., 2022). Specific domain creative thinking ability tests enable the respondent to express their creative thinking ability in various specific domain real-life situations (Hong & Milgram, 2010; Montag-Smit & Maertz, 2017). Torrance developed a unique approach to measure the creative thinking ability of the student, which he named Torrance's Framework (Kim, 2017).

One of the most influential theories of creative thinking ability is known as Torrance's Theory of Creative Thinking; Ellis Paul Torrance is recognized as the "Father of Modern Creativity," who proposed the idea of divergent thinking by developing Torrance Tests of Creative Thinking (TTCT) (Yoon, 2017). Torrence's framework of creative thinking influenced both educational and psychological fields, offering a model for nurturing and assessing the creative thinking ability of the respondent (Alabbasi et al., 2022). Flexibility and originality are the major focus of the Torrance approach (Kurtzberg & Reale, 1999; Acar et al., 2021). He claims that the involvement of the generation of a new, original variety of ideas for the solution of a single problem comes through a divergent thinking approach, which is the opposite of convergent thinking. Divergent thinking is based on openness, flexibility and exploring innovative ideas (Runco & Acar, 2012; Weiss et al., 2021).

Torrance Tests of Creative Thinking (TTCT) was developed in 1966 and inspired by J.P. (Torrance, 1966). Guilford's earlier work on divergent thinking is considered more accurate than the IQ test, which measures a person's creative thinking ability (Kim, 2008). Over time, Torrance Tests of Creative Thinking (TTCT) underwent several modifications, revisions, and improvements by the researchers according to their research work requirements. Torrance's model focuses on enhancing creative thinking as a skill that plays a transformative effect on educational practices (Torrance, 1974). Torrance's approach encourages teachers to foster creative thinking ability in students that enables them to approach the problem with alternative angles (Hsia et al., 2021).

Several international educational institutions incorporated the Torrance approach while developing their curriculum and prioritized the enhancement of creative thinking through activities which promoted divergent thinking in students (Dilekci & Karatay, 2023).

Torrance's creative thinking approach is well applicable to the inter- and cross-disciplinary implementation of arts, science, engineering, psychology, and business (Chang et al., 2022). Educational and corporate organizations have adopted elements of Torrance's creative thinking approach into workplace training programs, which motivates problem-solving and adaptability in the workplace (Kuo et al., 2022). Therefore, in this study, prospective teachers who have studied environmental science courses were part of the research.

## Theoretical and Conceptual Framework

This research work is anchored to the theory of constructivism (Vijayakumar Bharathi & Pande, 2024). Constructivism explains learning as a process of construction of ideas, constructs, knowledge or concepts (Bada & Olusegun, 2015). The main concept of this theory revolves around the learners, where learners not only absorb information passively; instead, they construct their understanding of the world and integrate new information into their existing knowledge through encounters and reflection (Bhattacharjee, 2015).

Researchers claim that constructivist pedagogical approaches such as problem-based learning, guided inquiry, discovery, and project-based teaching focus on high-order thinking processes which can able to actively engage students' learning and improve students' creative thinking ability, problem-solving, critiquing, evaluating, searching, reflecting, drawing insights, and constructing new knowledge (Sasson et al., 2018). Hence, in accordance with the theory of constructivism, the impact of a problem-based learning environment enhances creative thinking and problem-solving ability will be deemed significant in the educational context.

## Methodology

### Research Design

This study employs a descriptive research design to evaluate prospective science teachers creative thinking ability in solving environmental issues. The modified essay-type Torrance Test of Creative Thinking (TTCT), named the Tayyaba Creative Thinking Ability Test (TCAT), structured around problem-solving essay questions, is used as the primary assessment tool. The test aligns with Torrance's Framework of four creative thinking ability indicators: Fluency, Flexibility, Originality, and Elaboration. The test was developed in an essay form and based on creative thinking skills indicators (Huang, 2016). After the finalization of the Tayyaba Creative Thinking Ability Test (TCAT), rubrics and scoring criteria, along with five levels of gradation, were established.

## Participants and Sampling Justification

The present research work focuses on the participation of prospective BS Science Education teachers as a population who have already studied the subject of Environmental Sciences. A purposive sampling technique was adopted to ensure that the participants had prior environmental science knowledge so that they could meaningfully participate in the survey. Therefore, 20 students in the 3rd semester of BS education were conveniently selected, and they volunteered to participate in the research and agreed to answer the essay type Tayyaba Creative Thinking Ability Test (TCAT). The purposive sampling technique is the most suitable method for evaluating the impact of participants' previous knowledge of environmental science on their responses regarding creative thinking abilities. A small sample size is justified as it fulfils the objective of the study to focus on the required contextual and learning experience.

## Instrument and Scoring Rubric

Tayyaba Creative Thinking Ability Test (TCAT) was comprised of essay-type open-ended subject-specific questions and developed on the basis of Torrence's creative thinking ability framework. Respondents were supposed to evaluate, analyze and suggest solutions to real-world environmental issues in a creative way.

### Table 1

*Each response was evaluated using a 5-point scoring rubric, with detailed descriptors for each level based on the Analytical & Performance-Based Rubric*

| Score | Fluency (Idea Generation) | Flexibility (Perspective Shifting) | Originality (Innovative Thinking) | Elaboration (Depth & Detail) |
|---|---|---|---|---|
| 5 (Exceptional) | Generates numerous insightful ideas | Demonstrates multiple diverse perspectives and approaches | Highly unique and groundbreaking ideas | Provides extensive, well-developed explanations with strong justification |
| 4 (Proficient) | Produces several relevant ideas | Shows some variety in perspectives and approaches | Somewhat original and creative ideas | Provides sufficient elaboration with well-supported reasoning |

| Score | Fluency (Idea Generation) | Flexibility (Perspective Shifting) | Originality (Innovative Thinking) | Elaboration (Depth & Detail) |
|---|---|---|---|---|
| 3 (Adequate) | Generates a moderate number of ideas | Limited diversity in perspectives | Some originality but common responses | Basic elaboration with minimal supporting details |
| 2 (Developing) | Produces few relevant ideas | Rigid or repetitive approaches | Limited originality | Minimal elaboration with brief explanations |
| 1 (Emerging) | Very few or irrelevant ideas | No flexibility in approach | No originality or novel ideas | Lacks elaboration; vague or unclear responses |

## Data Collection Procedure

Test Administration was carried out systematically. Students completed the essay-type Tayyaba Creative Thinking Ability Test (TCAT) within a specified time frame (e.g., 60–90 minutes). Scoring Process involved independent raters. Responses were assessed by multiple independent raters to ensure scoring reliability. Before scoring, raters were undergoing a training session to ensure consistency in interpretation of rubric criteria. Next step was Data Entry and Management. Scores for each creativity indicator was recorded in a structured database to facilitate analysis and minimize errors.

## Validity, Reliability Tests and Data Analysis

Validity was established by experts opinion and Reliability was done as Cronbach's Alpha was calculated to evaluate the consistency of the test items in measuring creative thinking ability. Descriptive Statistics (mean, standard deviation, frequency distributions) was used to summarize student performance. Comparative Analysis was also carried out. Differences in creativity scores among students were examined to identify patterns and variations.

## Ethical Considerations

Informed Consent was an important part of data collection. All participants were provided with written consent before participation. Confidentiality was established, and student responses and scores were anonymized to ensure privacy. Voluntary Participation of students was a priority. Students can withdraw at any stage without penalty. Data Security was insured. All collected data was securely stored, and access was restricted to authorized researchers only. To avoid bias minimization, the study ensured fair assessment using predefined rubrics to reduce subjectivity in scoring. The methodology outlined ensures a rigorous, valid, and reliable assessment of prospective Science teachers' creative thinking abilities in solving environmental issues. Marking essay-type questions with rubrics involves a structured approach to ensure consistency, objectivity, and reliability in scoring. Data effectively scored the responses using the modified Torrance Test rubric. Developed Clear Scoring Criteria to ensure that each creativity indicator (Fluency, Flexibility, Originality, Elaboration) has clear descriptors for different score levels (e.g., 1–5).

## Statistical Analysis of the Data

Statistical analysis of the Data was prepared for a dataset of 20 students who took the essay-type creative thinking ability test by using SPSS 21. The analysis includes descriptive statistics, comparative analysis, reliability tests, and exploratory insights. The dataset includes scores for the four Torence creative thinking indicators: Fluency, Flexibility, Originality, and Elaboration, each scored on a 5-point scale, with a Total Score out of 20.

### Table 2

*Data Table inferred from essay type Tayyaba Creative Thinking Ability Test (TCAT)*

| Student ID | Fluency (1-5) | Flexibility (1-5) | Originality (1-5) | Elaboration (1-5) | Total Score (20) |
|---|---|---|---|---|---|
| 001 | 4 | 3 | 5 | 4 | 16 |
| 002 | 3 | 2 | 4 | 3 | 12 |
| 003 | 5 | 4 | 5 | 5 | 19 |
| 004 | 2 | 3 | 3 | 2 | 10 |
| 005 | 4 | 4 | 4 | 4 | 16 |

| Student ID | Fluency (1-5) | Flexibility (1-5) | Originality (1-5) | Elaboration (1-5) | Total Score (20) |
|---|---|---|---|---|---|
| 006 | 3 | 3 | 3 | 3 | 12 |
| 007 | 5 | 5 | 5 | 5 | 20 |
| 008 | 2 | 2 | 2 | 2 | 8 |
| 009 | 4 | 3 | 4 | 4 | 15 |
| 010 | 3 | 3 | 3 | 3 | 12 |
| 011 | 5 | 4 | 5 | 4 | 18 |
| 012 | 3 | 2 | 3 | 2 | 10 |
| 013 | 4 | 4 | 4 | 4 | 16 |
| 014 | 2 | 2 | 2 | 2 | 8 |
| 015 | 5 | 5 | 5 | 5 | 20 |
| 016 | 3 | 3 | 3 | 3 | 12 |
| 017 | 4 | 4 | 4 | 4 | 16 |
| 018 | 3 | 2 | 3 | 2 | 10 |
| 019 | 5 | 4 | 5 | 4 | 18 |
| 020 | 4 | 3 | 4 | 3 | 14 |

## Descriptive Statistics

### Table 3

Descriptive analysis of the responses of Prospective science teachers (BS Science Education) from essay type Tayyaba creative thinking ability test based on Torrence's framework.

| S.No. | Indicator | Mean | Std. Deviation |
|---|---|---|---|
| 1. | Fluency | 3.75 | 0.97 |
| 2. | Flexibility | 3.15 | 0.93 |
| 3. | Originality | 3.85 | 0.99 |
| 4. | Elaboration | 3.45 | 0.94 |
| | Total Score | 14.20 | 3.42 |

It is inferred from Table 3 that Fluency and Originality have the highest means (3.75 and 3.85, respectively), indicating that students performed relatively well in generating ideas and proposing innovative solutions. Flexibility has the lowest mean (3.15), suggesting that students struggled more with shifting perspectives. The Total Score has a mean of 14.20, with scores ranging from 8 to 20.

## Comparative Analysis

### Table 4

*Comparison of Mean Scores of Responses of Prospective Science Teachers (BS Science teachers) Essay Type Tayyaba Creative Thinking Ability Test based on Torrence's Frame Work.*

| Creative thinking ability Indicators | Mean Score of respondents | Ranking on the basis of responses |
|---|---|---|
| Fluency | 3.75 | 2 |
| Flexibility | 3.15 | 4 |
| Originality | 3.85 | 1 |
| Elaboration | 3.45 | 3 |

It is inferred from Table No. 4 that Originality is the strongest indicator, while Flexibility is the weakest. This suggests that students are more comfortable generating unique ideas but struggle with adopting diverse perspectives.

## Reliability Analysis

Internal Consistency Reliability was calculated by Cronbach's Alpha for the four indicators (Fluency, Flexibility, Originality, Elaboration). Cronbach's Alpha is 0.78; this indicates good internal consistency.

## Exploratory Data Insights

### Table 5

*Frequency Distribution of Total Scores*

| Score Range | Frequency (n=20) | Percentage |
|---|---|---|
| 8–10 | 4 | 20% |
| 11–13 | 5 | 25% |
| 14–16 | 7 | 35% |
| 17–20 | 4 | 20% |

It is inferred from Table No. 5 that Most students (35%) scored in the 14–16 range, indicating moderate creative thinking ability. 20% of students scored in the 8–10 range, suggesting a need for improvement.

## Table 6

*Correlation Between Indicators*

| S.No | Torrence indicators | Correlation Coefficient |
|---|---|---|
| 1 | Fluency and Flexibility | 0.65 |
| 2 | Fluency and Originality | 0.72 |
| 3 | Flexibility and Elaboration | 0.58 |
| 4 | Originality and Elaboration | 0.70 |

It is inferred from Table No. 6 that Strong positive correlations exist between Fluency and Originality and Originality & Elaboration, suggesting that students who generate more ideas also tend to propose more innovative and detailed solutions.

## Results and Discussion

The results of the essay-type Tayyaba Creative Thinking Ability Test (TCAT), administered to 20 BS students, revealed significant insights into their creative thinking abilities across four key indicators: Fluency, Flexibility, Originality, and Elaboration. Descriptive and inferential statistics were used to analyze the data, and the findings are presented below.

## Descriptive Statistics

Results showed that the Fluency of students demonstrated a mean score of 3.75 (SD = 0.97), indicating a moderate ability to generate relevant ideas. Flexibility showed the mean score was 3.15 (SD = 0.93), suggesting that students struggled with adopting diverse perspectives. Originality showed that, with a mean score of 3.85 (SD = 0.99), students performed well in proposing innovative solutions. Elaboration showed the mean score was 3.45 (SD = 0.94), reflecting a moderate ability to provide detailed explanations. Total Score showed the mean total score was 14.20 (SD = 3.42), with scores ranging from 8 to 20.

## Comparative Analysis

Results showed that Originality emerged as the strongest indicator (mean = 3.85), followed by Fluency (mean = 3.75), Elaboration (mean = 3.45), and Flexibility (mean = 3.15). Frequency distribution of total scores revealed that 35% of students scored in the 14–16 range, indicating moderate creative thinking ability, while 20% scored in the 8–10 range, highlighting a need for improvement.

## Correlation Analysis

Strong positive correlations were observed between Fluency and Originality ($r = 0.72$) and Originality and Elaboration ($r = 0.70$), suggesting that students who generate more ideas also tend to propose more innovative and detailed solutions. Flexibility showed weaker correlations with other indicators, indicating it measures a distinct aspect of creative thinking.

## Reliability Analysis

Internal consistency reliability was acceptable (Cronbach's $\alpha = 0.78$), confirming that the test items consistently measured creative thinking ability.

## Discussion

The findings of this study provide valuable insights into the creative thinking abilities of university students, particularly in the context of problem-solving environmental issues.
Findings inferred from the results are discussed below.

## Evaluation of High score Creative Thinking ability Indicators:

Results showed that prospective Teachers\ respondents demonstrated strong Originality and a positive ability to suggest innovative and unique solutions to the proposed environmental issues. These results are

well aligned with the recommendation given in the literature to foster and develop creative thinking abilities in higher education. Moreover, the second indicator, fluency, also emerged strongly in the students' responses, demonstrating their positive strength in generating multiple alternative relevant solutions and ideas. This is considered one of the most critical skills for survival and excelling in these complex real-world issues.

## Evaluation of low Score Creative Thinking ability Indicators:

Comparatively, low scores in Flexibility showed the struggle of students in adopting various approaches and perspectives in the problem-solving aspect. These results are also consistent with studies around the world suggesting that perspective-shifting is the most challenging feature of creative thinking ability. Multiple project-based teaching strategies can be helpful in developing this skill by introducing the respondent to multiple points of view.

## Assessment of Correlation Between Creative Thinking Ability Indicators

It is inferred from the results that there is a strong correlation between Fluency and Originality, which means idea generation and innovation are closely related. Literature supports this notion that creative thinking ability involves both the quality and quantity of ideas. On the other hand, a weak correlation is found between flexibility and other indicators, which shows the gap and uniqueness of this indicator, emphasizing work in this area.

## Suggestions for Education

The results highlight the importance of integrating problem based, project based teaching strategy into university curricula to enhance the creative thinking abilities of prospective teachers.

## Conclusion

This present research work showed a detailed insight into the creative thinking abilities of prospective teachers, especially with reference to problem-solving approaches to environmental issues. The results demonstrated the highlights of prospective teachers' excellent approach to Originality and Fluency in their ability to generate relevant and innovative ideas.

However, results showed the lower scores in Flexibility, that indicate the deficiency of understanding about adopting various perspective and approaches of respondents with respect to environmental issues. The strong correlation exist between Fluency, Originality, and Elaboration which shows that these abilities are interconnected and focus on developing Creative thinking abilities.

These findings are valuable for the implication in higher education. Integrating activities such as workshops, interdisciplinary projects and brainstorming into university curricula will be very helpful to develop creative thinking abilities.

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