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The Impact of Metacognitive Strategy Instruction on Creative Problem-solving Performance among University Students

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DECLARATION

I declare that I have created the thesis by myself. All sources and literature used have been duly cited. The work was not used to obtain another or the same title. This declaration and consent will be signed by handwritten signature.

In Prague, Czech Republic Signature:

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Abstract: Higher education demands that students not only acquire domain-specific knowledge but also develop effective skills for solving ill-defined (non-routine) problems, such as writing an essay or completing end-of-the-book exercises. In their article, Urban & Urban (2023) suggested that applying metacognitive skills is crucial for solving ill-defined problems. However, there is a limited amount of experimental research conducted in university settings on this subject. This study investigates the impact of metacognitive instruction on creative problem-solving performance among 79 university students, with one experimental group of 29 participants receiving instruction in both creative problem-solving and metacognitive strategies, another experimental group of 22 receiving only knowledge about creative problem-solving and a third control group of 28 receiving no instruction. No significant impact of the instruction was observed among experimental conditions, prompting a call for deeper investigation and refinement of metacognitive interventions in creative problem-solving research. Suggested directions for improvement include prolonged instructional sessions and the incorporation of diverse practice tasks tailored to participants' interests.

Keywords: Metacognition, Metacognitive Strategy Instruction, Creative Problem-Solving, Complex Problem-Solving, Higher Education

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1. Introduction

In today's era of rapid change and development, creativity has been recognized as an essential twenty-first-century skill (Isaksen, 2023; Kaufman & Begretto, 2009; Lucas & Venckuté, 2020; World Economic Forum, 2020). Contrary to the belief that creativity is an innate talent reserved for a selected few (Galton, 1869), recent research suggests that it can be learned and developed (Beghetto & Kaufman, 2007; Lizarraga et al., 2009; Ritter et al., 2012; Scott et al., 2004; Sternberg & Lubart, 1996). Moreover, since the early 20th century, there has been a growing body of evidence stating that developing creative abilities can lead to an improvement in people's quality of life - from small daily enhancements to significant innovations that can change the world (Isaksen, 2023; Kaufman & Beghetto, 2009; Karwowski & Kaufman, 2017; Lucas & Venckuté, 2020). Hence, there is a clear need to direct the research efforts towards enhancing existing creative thinking interventions and developing new ones to improve individuals' creative abilities in the rapidly evolving world (Isaksen, 2023).

Contemporary learning theories have highlighted the importance of metacognitive awareness in creative outcomes (Cropley et al., 1998; Feldhusen and Goh, 1995; Jaušovec, 1994; Scherer et al., 2012; Sternberg, 1998; Urban et al., 2021). Metacognition allows individuals to reflect on their thinking, plan their approaches to tasks, monitor their progress, and evaluate their strategies and outcomes (Brown, 1978; Schunk & Zimmerman, 1998).

Urban and Urban (2023) suggested that individuals who show a lack of metacognitive skills may not exhibit high levels of creativity. Therefore, interventions targeting the enhancement of metacognitive awareness have been suggested as effective means of improving performance in creative problem-solving. Several studies have demonstrated that instructing individuals in creative problem-solving strategies within domain-relevant tasks, alongside metacognitive regulation strategies, enhances outcomes in creative problem-solving (e.g., Hargrove & Nietfeld, 2015; Jaušovec, 1994). However, any research solely focusing on the impact of metacognitive strategy instruction on creative outcomes has not been encountered by the author. Therefore, this study aims to address this gap by investigating how metacognitive instruction influences individuals' ability to solve creative problems.

2. Research on Creativity

Although the definitions of creativity may vary to some extent, a widely accepted academic perspective suggests that creativity represents the ability to generate ideas, work, or solutions that are both original (novel, unique) and useful (socially valued and meeting the task constraints; Briskman, 1980; Hocevar, 1981; Mansfield, 1980; Mumford & Gustafson, 1988; Sternberg & Lubart, 1996; Zhang & Sternberg, 2011). Moreover, creativity is widely recognized as an ability that can be acquired through learning (e.g., Lizarraga, et al., 2009; Ritter et al., 2012; Scott et al., 2004; Sternberg & Lubart, 1996; Torrance, 1987). However, this acknowledgement was not always there. In fact, it wasn't until the early 20th century that creativity was thought to be an attainable ability (Pope, 2005).

2.1. History of Creativity Research

From ancient Greek philosophies to modern psychological studies, the concept of creativity has evolved significantly over time. Tatarkiewicz (1980) states that the act of creation was not specifically named in ancient Greek. The closest word, "poiein" (to make), was mainly applied to the act of poetry. This mirrored the Greek understanding of art ("techne"), which was defined as "the making of things according to rules," devoid of originality. The Greeks believed that creative elements were undesirable in art. In The Republic (Bloom & Kirsch, 1968), Plato characterized painting and sculpture as mere imitation rather than acts of creation. Poetry, however, was an exception to this perspective. Poets were perceived as creators who brought forth new worlds via their work, in contrast to other artists, who were thought to be only mimics. Even though the ability to visualize, anticipate, and produce innovative ideas did not have a name at that time and was not associated with creativity, it was a highly valuable skill. Socrates recognized its importance and nurtured it in his educational approach by asking provocative questions and encouraging natural ways of learning (Torrance, 1965).

The implications of creativity were more inclusive in the Roman period, yet they still predominantly revolved around artistic skills. The verb “to create” existed in Latin language as creare (meaning “to create”) and facere (meaning “to make”). In the Roman Empire, the capability of "making" was extended to artists beyond those of the written word (Tatarkiewicz, 1980).

During the Middle Ages, as Christianity spread, the divine inspiration mentioned by Callistratos was further developed, leading to a change in the meaning of the word "creation." The term "creatio" came to represent God's act of "creation from nothing" ("creatio ex nihilo") (Tatarkiewicz, 1980). This concept of "creatio" excluded human agency from the creative context, portraying humans as a vessel for the expression of the divine creation (Chan, 2015).

It was not until the fourteenth century that the human agency regained prominence as a creator rather than a mere channel. According to Chan (2015), the Renaissance marked a shift where inspiration and its artistic expression were attributed to human beings. For instance, Leonardo da Vinci began employing previously unseen shapes, while Michelangelo manifested his imagination in his art rather than simply imitating nature. This era saw a rebirth of creative genius, which was cultivated within human nature (Tatarkiewicz, 1980).

Runco and Albert (2010), however, state that the transition from divine to individual inspiration didn't become apparent until the rise of the Age of Enlightenment. As the mindset shifted towards science and discovery, creative thinking emerged as a highly valued skill. In their paper, the authors highlight its significance by quoting Thomas Hobbes: "Imagination became a key element of human cognition." Scientific thinking gave birth to the idea of research as a primary instrument for the discovery of the physical world and the human role in it.

The first scientific research on the study of creativity dates back to the late nineteenth century. In his essay on Original Genius, Willian Duff (1767) first analyzed the nature of genius as a property of human psychology and identified imagination as a quality of genius (Dacey, 1999). Darwinism and the research on human evolution through genetic improvement inspired further scientific interest in creative thinking. Particularly Francis Galton published his book called Hereditary Genius in 1869 where he studied the heritability of intelligence, with creativity taken as an aspect of genius. His analysis of 415 individuals with hypothesized biologically inherent natural abilities led him to two main conclusions: firstly, no man could achieve an extremely high reputation without being gifted with remarkably high abilities, and secondly, few who possess those very high abilities could fail in achieving eminence (Galton, 1869). Following research by such scientists as Catharine Cox (1926), and Lewis Terman (1954) was primarily focused on identifying intellectually gifted children and tracking their development over time, yet it also highlighted the connection between genetics and environmental factors in the expression of intellectual ability.

According to Chan (2015), the focus in psychology during the early twentieth century shifted from comparing geniuses to learning more about the creative aspects of intelligence. In his inaugural speech at the American Psychological Association (APA) in 1950, J. P. Guilford argued that the domain of creativity was a critically understudied area, and it requires further research. He claimed that intelligence test scores should not be regarded as a definitive measure of individual or group superiority. For instance, individuals with the highest levels of creativity might exhibit lower scores on conventional IQ tests due to their tendency to generate a broader array of potential solutions, some of which are novel and original (Chan, 2015). He also raised the question of why schools weren't nurturing more creativity and addressed the minimal link between education and creative productivity. This speech has been dubbed by Professor Guilford's successors as "The 1950 speech that sparked creativity research" (Beghetto, et al., 2001; Kaufman & Beghetto, 2009; Pope, 2005). Since then, research on creative thinking has advanced rapidly. The ideas previously laid out by such scientists as Guilford himself, Spearman (1931), Dimnet (1929), and Wallas (1926) were further developed and elaborated on by the growing academic community aiming to comprehend the cognitive processes that influence creative thinking and identify the factors that enhance creative output.

The journey of creativity from ancient times to the present day reflects the evolving human understanding of the creative process. From Greek skepticism to Renaissance revival and scientific inquiry, creativity has captivated research and fueled innovation across diverse domains. The evolution of creativity reflects not only shifts in cultural perspectives but also advancements in our understanding of cognitive processes and individual differences. As we continue to study the complexities of creativity, it becomes increasingly evident how important creative skills are for transformative progress in human society.

2.2. Rationale for Investigating Creative Skills

As scholars gained a deeper understanding of creative processes, they began to recognize the significance of human creativity (Chan, 2015). For instance, in his work, Osborn (1958) defined creativity as one of the fundamental mental powers, placing it alongside three others: (1) Absorptive power, the capacity for observation and focused attention; (2) Retentive power, the faculty of memorization and recall; (3) Reasoning power, the ability for analysis and sound judgment. Finally, he highlighted (4) Creative power, the ability to visualize, anticipate, and produce innovative ideas. He also suggested that through the first two functions learning is facilitated, while the latter two facilitate critical thinking.

Osborn saw that the predominant focus of education in his era was on absorption and retention, neglecting the cultivation of creativity. According to the article, both our life experiences and formal education tend to prioritize the development of judgment, sometimes overshadowing our creative potential and resulting in a decline in critical thinking abilities as we transition from childhood to adulthood. Alongside Guilford and Osborn, other researchers studying creative thinking processes advocate for a shift in educational paradigms to allow a more creative form of education. For example, Torrance expressed his views as far back as 1965 in his article by stating: "We have made enough advances in educational thinking to make a more creative kind of education possible. The major questions facing us now are: Will we choose to use these advances in knowledge and thinking and will we choose in time? I believe we have reached a stage in history when we must make such a choice. In the past, we have been able to survive with static goals and concepts. Change is occurring so rapidly that we cannot survive if we insist on thinking and living in static terms. We must accept the creative challenge!," (Torrance, 1965).

Torrance talked about rapidly occurring change almost six decades ago, when in his article, Isaksen (2023) points out that it took 25 years to double our knowledge in 1945—and now some assert that it doubles every 12 hours, citing Fuller (1981) and Chamberlain (2020). In the present era of change and development, creativity has been recognized as an essential twenty-first-century skill (Isaksen, 2023; Kaufman & Begretto, 2009; Lucas & Venckuté, 2020; World Economic Forum, 2020). Isaksen also states that it is important to study creativity because of two more reasons. Firstly, there is a wealth of research evidence that creative potential could be developed, as demonstrated in their compendium of 1200 studies supporting the learning and application of the Osborn-Parnes tradition of creative problem-solving and its modifications (Isaksen, 2022a). Additionally, in the revised Bloom's taxonomy, creativity is seen as the highest learning goal. While remembering, understanding, applying, analyzing, and evaluating information are important, the key is to combine different pieces of information to create something new (Rahman & Manaf, 2017). Secondly, he says that there is a growing body of evidence suggesting that developing creative abilities can lead to an improvement in people's quality of life (Isaksen, 2023; Karwowski & Kaufman, 2017; Lucas & Venckuté, 2020).

Considering the aforementioned factors, creativity is widely recognized as a highly valuable human ability. It is acknowledged that creativity can be learned and enhanced in every individual through deliberate efforts. Moreover, developing creative skills is associated with positive outcomes at both the individual and societal levels.

2.3. Theoretical Framework for Understanding Creativity

The current theoretical frameworks offer diverse ways of approaching creative abilities. According to Kaufman & Begretto (2009), most studies on creativity generally follow one of two paths. The first direction continues to study eminent creativity, with a focus on understanding the creative genius and discussing enduring creative works that may stand the test of time (e.g., Gruber, 1981; Simonton, 1994). The authors term this research Big-C creativity studies. Another predominant area of research centers on creativity in everyday life (e.g., Amabile et al., 1996; Baer & Kaufman, 2005; Beghetto & Plucker, 2006; Cropley, 2006), studying abilities that ordinary people can benefit from across various aspects of their lives, such as combining clothes of different styles to find a unique look, planning a birthday party, or cooking a new dish using leftovers from the refrigerator. Much of the research in educational and social psychology is devoted to exploring this form of creativity, referred to as little-c creativity.

However, they pointed to the limitations of this binary approach, as some of the research did not exactly fit into the categories of little-c or Big-C. By focusing on only the two categories we face a risk of overlooking the creative potential of children or students and the professional-level creativity of expert creators. Therefore, the authors propose two additional forms of creativity: mini-c and pro-c creativity. Mini-c is defined as the unique and personally meaningful interpretation of experiences, actions, and events (Beghetto & Kaufman, 2007). Including mini-c in our understanding of creativity adds a necessary level of specificity to ensure that children's creative potential is recognized and nurtured rather than overlooked (Kaufman & Beghetto, 2009).

Another category offered by Kaufman and Beghetto (2009), Pro-c, stands for the next developmental stage of little-c, characterized by sustained effort and advancement toward Big-C creativity, though it has not yet achieved that level. Not all professionals working in creative fields will necessarily step up to the Pro-c status. The concept aligns with the expertise acquisition perspective of creativity proposed by Ericsson (1996), which suggests that notable creators typically require around a decade of dedicated practice and expertise in a specific domain to attain world-class expert-level proficiency, although this period may vary. The authors suggest that the Four-C model can serve as a platform for integrating previous theories and research on creativity, as well as help identify areas in need of further exploration.

Hargrove and Nietfeld (2015) see Kaufman and Beghetto's Four-C model as an unfolding trajectory of creativity evolution. It begins with novel and individually meaningful ideas that are processed by past experiences during the knowledge acquisition stage (mini-c). Little-c creativity, or external representations of creativity from everyday events, comes next on the continuum. The next step is achieved with dedication and skill evolution (pro-c). Finally, the highest end on the creative continuum shows widely recognized examples of eminent creativity that are referred to as Big-C creativity. Moving from individually relevant and unrecognized creative processes to externally recognized creative outcomes is the way to get from mini-C to Big-C.

Ross Mooney (1963) outlined four approaches to holistically investigate creative talent, which include examining the creative environment, viewing the product as an outcome of creativity, analyzing the creative process, and understanding the traits of the individual engaging in the creative act. Taylor (1988) elaborated on these four approaches concluding a formula where the creative process and resulting product are the primary indicators of creativity, with the creative individual being the essential factor in the equation. Environmental factors are a modifier and stimulus, facilitating the activation of internal creative processes. It encouraged further research to center around four main areas: an examination of the personality traits that contribute to creativity (personality), the investigation into the environmental factors that foster creativity (creativity stimulation), an exploration of the cognitive processes involved in creativity (cognition and newly metacognition), development and utilization of assessments to measure creativity (measurement) (Chan, 2015).

2.3.1. Personality Traits and Creativity

The study of creative personality traits has been widely explored since the twentieth century (e.g., Barron, 1955; Brolin, 1992; MacKinnon, 1965; Shaw & Runco, 1994). They have identified key positive traits such as intellectual curiosity, deep commitment, independence in thought and action (Urban & Urban, 2023 found that students who are better able to monitor their performance independently, scored higher on creativity tasks), a strong desire for self-concept, a strong sense of self, openness to impressions, high sensitivity, and a high capacity for emotional involvement. Additionally, they have noted negative traits like dogmatism, conformism, narcissism, frustration, resilience, elation, hypomania, and affect tolerance that are associated with creative individuals (Chan, 2015).

A significant body of research indicates a strong correlation between creative performance and the level of intrinsic type of motivation (e.g., Amabile, 1988; Collins & Amabile, 1999; Runco, 2010; Sternberg & Kaufman, 2010; Urban et al., 2021), a weak positive correlation was also found between creative performance and extrinsic identified regulation (Urban et al., 2021). Amabile (1997) identified motivation as a critical variable for creative outcomes.

Kaufman & Begretto (2009) believe that at the Pro-c (and Big-C) level, both intrinsic and extrinsic motivation contribute to initiating and maintaining creative activity. There is, however, a greater demand for intrinsic motivation at the mini-c and little-c levels. They explain that because an individual's interest and commitment in the domain are still emerging, external pressure or a reward may be dangerous for a child as they might eliminate or replace their natural interest.

2.3.2. Environmental Factors and Creativity

While creativity has been acknowledged as a mental process (Osborn, 1954), it is also regarded as a product of cultural recognition and social judgments within an environment (Chan, 2015). Such scholars as Amabile & Gryskiewicz (1989), Hennessey (2010), Woodman, Sawyer, and Griffin (1993), made significant contributions to the field of social psychology research on social-environmental influences on creative performance. Amabile et al. (1996) proved that the social environment can influence both the level and the frequency of creative behavior.

In the componential model of creativity and innovation organizations (Amabile, 1988), three broad organizational factors are presented: (1) organizational motivation to innovate, (2) resources (significant time, access to domain-specific materials), (3) management practices oriented towards autonomy and freedom. Woodman, Sawyer, and Griffin (1993) further expanded on the componential theory by incorporating additional dimensions. They not only considered internal organizational factors but also external influences. Their model emphasizes the interaction between individual factors and environmental inputs in shaping creative behavior within organizations. In their model, creative behavior is influenced by two main categories of factors: (1) group characteristics, including norms, cohesion, diversity, roles, task attributes, and problem-solving approaches within the group, (2) organizational characteristics, such as structure, resources, rewards, strategy, technological focus, and overall organizational culture.

2.3.3. Cognitive Processes in Creativity

Isaksen (2023) asserts that he and his colleagues (Dorval K. B., Noller R.B., Geuens, D., Kaufmann, A. H., Parnes et al.) have always been strong believers in the power of one process, specifically referring to the creative problem-solving (CPS) process. Noller (1979) offered a thorough explanation of CPS by defining each word: creative, problem, and solving. Here, "creative" means having an element of newness and being relevant at least to you, the solution's creator. "Problem" stands for any situation which presents a challenge, offers an opportunity, or is a concern to you. "Solving" means devising strategies to answer or to meet or satisfy the problem, adapting yourself to the situation, or adapting the situation to yourself. Creative problem-solving or CPS is a process, a method, or a system for approaching a problem in an imaginative way resulting in effective action (Isaksen, 2023).

As well as Isaksen, Mumford et al. (1991) states that without an initial problem representation, a creative product cannot be brought into existence. He elaborates that a set of mental processes known as cognition is needed to come up with a solution for the problem. In particular, he draws attention to two fundamental components of cognition: knowledge, or an organized comprehension of facts and ideas about a certain domain, and cognitive processes, which involve effectively applying this knowledge to produce ideas.

However, the author argues that creative problem-solving may require specific conditions which are not present in other types of problem-solving, as it appears when the generation of complex solutions is required, the ones which need to be proven novel and socially valued. Therefore, Mumford distinguishes four characteristics specific to CPS:

1. It occurs when dealing with ill-defined or ill-structured problems.

Jonassen (2011) distinguishes well-structured and ill-structured types of problems. Well-structured problems imply clear requests and look for one straightforward solution, whereas ill-structured ones lack clear problem statements, solution paths, and resources to be used in the problem-solving process. Mumford realizes that CPS cognitive processes can only be initiated when encountering complex, ill-defined problems.

2. It requires both divergent and convergent thinking.
3. There is a need for balancing convergent and divergent thinking.

The first distinction between the concepts of divergent and convergent thinking was introduced by Guilford (1948). He stated that convergent thinking aims for a single, correct, or best solution to a problem, and divergent thinking is used for the generation of multiple solutions to an open-ended question. Although Guilford's divergent thinking was equated with creativity in psychology literature, Runco (2023) argues against this, emphasizing the difference between the two. Creative thinking produces novel useful solutions, whereas divergent thinking is there for generating as many ideas as possible, whether original and socially valued or not. Therefore, Mumford emphasizes the need for a balance between divergent and convergent thinking to develop truly original solutions. CPS requires divergent thinking to explore different ideas and convergent thinking to evaluate them and hypothesize the best possible solution to a problem.

4. It is related to the application of existing knowledge.

It appears that the processes of systematic combining and rearrangement of preexisting categories play a significant role in giving birth to novel solutions (Hodder, 1988; Mumford, 1991; Mumford & Gustafson, 1988; Mumford & Mobley, 1989; Rothenberg, 1988).

According to Mumford, many attempts have been made to create a universal, cross-domain, Process Model of CPS that is aimed at facilitating the identification and development of creative potential. One of the first models which was focused solely on creative idea generation was proposed by Graham Wallas in 1926. He suggested that there were four stages of CPS: (1) preparation (exploration of the problem) (2) incubation (internalization into the unconscious mind) (3) illumination or insight (sudden appearance of a solution), (4) verification (elaboration, and then application of the idea).

Wallas's model has served as a foundation for later elaboration by different scholars. For instance, Osborn together with his protégé, Sidney J. Parnes conducted a two-year experimental study to examine the effects of deliberately developing creativity called the Creative Studies

Project (Isaksen, 2023). Their efforts created a 5 stage Osborn-Parnes CPS model, which included (1) fact-finding, (2) problem-finding, (3) idea-finding, (4) solution-finding, and (5) acceptance-finding. In this model, they moved away from the “magic” illumination process rather focusing on idea-finding and solution-finding processes. Further models have been put out to outline the basic mechanisms of CPS, progressing our understanding of creativity from an enigmatic, hereditary ability to a dynamic, purpose-driven set of cognitive processes (e.g., Merrifield et al., 1962; Amabile, 1983; Busse & Mansfield, 1980; Silverman, 1985).

In his effort to organize the existing body of research, and identify a general underlying set of core processes, Mumford (1991) has outlined five key assumptions in the core of the proposed process models: (1) CPS ability depends on existing knowledge, (2) CPS would not work relying solely on existing knowledge, (3) combination and reorganization of preexisting information produces new knowledge, (4) effective combination and reorganization attempts results in the fresh, new combinations, that give a basis for the development of creative ideas, and (5) proactive, ongoing assessment and improvement of concepts will inevitably result in original problem-solving. Based on the assumptions, he formulated an eight-item CPS process model: (1) problem definition, (2) information gathering, (3) concept selection, (4) conceptual combination and reorganization, (5) idea generation, (6) idea evaluation, (7) implementation planning, (8) adaptive monitoring.

In his article from 2019, Mumford describes the research that has been conducted since he first published the model in 1991, showing that it provides sufficient evidence for the relevance of each of these processes to CPS. More specifically, it has been proven that each of the core processes contributes to an individual's performance in different ill-defined tasks; how well these processes are carried out affects how original and useful the solutions will be; these processes can be applied in various domains; poor performance in later stages, such as information gathering, may result from mistakes made in previous stages, such as problem definition.

Mumford's (1991; 2019) core process model and its evidence findings are highly valuable, as they contribute to understanding and further development of creativity measurement and educational and training interventions aimed at boosting creative performance.

2.3.4. *Assessment of Creativity*

The measurements can be structured following Mooney's (1963) four components of the holistic approach to studying creativity (personality, process, environment, and product).

Creative Personality Assessment

Tests like the 30-item Creative Personality Scale (CPS) for the Adjective Check List (Gough, 1979) assess personality traits associated with creativity, such as openness to experience, originality, and independence of judgment. Additionally, the Runco Ideational Behavior Scale (RIBS) (Runco et al., 2001) can be applied to measure the frequency and originality of individuals' ideas and creative behaviors in different domains.

Creative Process Assessment

A group under the supervision of J. P. Guilford designed an inventory of performance-based tests in 1967 for assessing divergent thinking skills, which marked the beginning of one of the first studies in contemporary psychometric research on creativity. The offered components of divergent thinking, sensitivity (the ability to identify problems), fluency (the ability to generate a variety of ideas), and flexibility (the ability to adjust to various task constraints), were assessed using tests such as Plot Titles, Quick Responses, Unusual Uses, Remote Associations, and Remote Consequences (Guilford, 1957). Expanding upon Guilford's research, Torrance (1974) designed the Torrance Tests of Creative Thinking (TTCT), which incorporated a combination of divergent thinking tasks and other problem-solving skills.

The tasks were organized into three distinct groups, each tailored to engage participants' cognitive faculties through different stimuli and methodologies. The first cluster encompassed verbal tasks employing verbal stimuli, with tasks such as Unusual Uses, Impossibilities Task, Consequences Task, Just Suppose Task, Situations Task, Common Problem Task, Improvement Task, Mother-Hubbard Problem, Imaginative Stories Task, and Cow Jumping Problems. The second group contains verbal tasks utilizing nonverbal the Incomplete Figures Task, stimuli, offering tasks like the Ask and Guess Task, Product Improvement Task, and Unusual Uses Task, thereby testing their ability to bridge verbal and nonverbal modalities. Lastly, the non-verbal tasks also referred to as Figural, constituted the third group, presenting tasks like Picture Construction Task or Shapes Task, Circles and Squares Task, and Creative Design Task, which demanded visualspatial reasoning and problem-solving skills. The presented solutions are evaluated according to four criteria: fluency, flexibility, originality, and elaboration (the depth of details) (Torrance, 1974).

According to Sternberg (2006), the TTCT remains the most popular method used to evaluate creative ability. Baer (2011), however, argues that misinterpretations of Torrance Test scores as indicators of general creativity and critical thought may lead to inaccurate research outcomes and inefficient interventions, as reliance on tests like the "unusual uses" may perpetuate misconceptions about creativity, measuring the divergent thinking abilities only and overlooking the convergent thought. Therefore, it is important to evaluate not only the uniqueness and quantity of the ideas but also their usefulness and elaboration.

Creative Environment Assessment

The Work Environment Inventory, or WEI, was designed in 1989 by Amabile and Gryskiewicz to assess the workplace's creative accelerators and barriers. It focuses on determining which characteristics of the workplace are most likely to affect the way creative ideas are expressed and developed. The WEI is a tool for fostering organizational growth intended to improve the creative climate. It has been optimized to apply to different organizational levels and roles. Another assessment tool, the Creative Environment Perceptions Scale offered by Mayfield and Mayfield (2010), evaluates three intricately linked environmental factors: creativity support, work characteristics, and creativity blocks (Surkova, 2012).

Creative Product Assessment

According to Surkova (2012), a standardized method for assessing creative products, Creative Product Analysis Matrix (CPAM), was initially introduced by Besemer and Treffinger in 1981 and then revised by Besemer and O'Quin in 1986 (Besemer & O'Quin, 1999). Three main aspects are evaluated by CPAM: novelty (uniqueness); resolution (usefulness); elaboration and synthesis (style and production values).

Taylor's Creative Product Inventory (CPI), which was developed in 1975, is another early instrument for evaluating product originality. Aspects like generation, reformulation, originality, relevancy, hedonics, complexity, and condensation are evaluated in this inventory (Surkova, 2012),.

Among the verbal tasks with nonverbal stimuli within TTCT, the Product Improvement Task (PIT) stood out as a tool for creative product assessment (Puente-Díaz et al., 2021). It presented participants with a product such as a common toy and encouraged them to brainstorm as many as possible ways to enhance the products' appeal and usefulness factor. Participants were asked to use their creativity and come up with both original and useful enhancements that could render the toy as "more fun to play with." Furthermore, the task challenged individuals to think of unconventional uses for these toys that would go beyond their typical function. According to Urban et al. (2021), The Product Improvement Task is the most complex creativity test that evaluates one's ability to come up with novel and valuable ideas in the pre-existing category.

Due to the differing abilities of individuals engaging in creative activities, it can be difficult to identify the key factors which measure and stimulate creativity. It is important to treat all variables equally, independent of where they sit on the assessment scale. Therefore, it is advised to use multiple types of tests with a range of assessment criteria to truly comprehend the complexity of creativity and differences among creators (Kaufman et al., 2013).

2.4. Interventions for Enhancing Creative Performance

Enhancing an individual's creative thinking has received a lot of attention as research on creative capacities progresses. The interventions have been developed for both domain-specific (e.g., Clapham & Schuster, 1992; Kvashny 1982;) and domain-general (Baer, 1998; 2011; Gordon, 1961; Isaksen, 2023; Mumford, et al., 2019; Osborn 1952, 1953) creative thinking enhancing. Empirical research, as noted by Hargrove and Nietfeld (2015), demonstrates that well-planned interventions can improve participants' outcomes in CPS. They identify common features of successful intervention designs, including:

1. The use of meaningful or domain-relevant tasks.

Meaningful tasks are those that are relevant and applicable to the specific domain or context in which individuals are seeking improvement. For instance, Hargrove and Nietfeld (2015) demonstrated the effectiveness of a creativity enhancement intervention in design students by focusing on introducing CPS strategies directly relevant to the design field.

2. The use of extended/distributed training sessions.

Hargrove and Nietfeld (2015) show the effectiveness of the distributed over-time interventions on the curious examples of Garaigordobil (2006) and Dow and Mayer (2004) studies. The first one focused on 10–11-year-old Spanish elementary school students. Throughout the school year, one group of students participated in weekly activities that emphasized creativity through play and cooperation, while another group did not. The results showed significant advantages for the group that engaged in the creative activities, particularly in verbal and graphic-figural creativity.

Dow and Mayer's (2004) study focused on college students and introduced brief interventions. Participants were required to individually read training packs for 15 minutes to prepare for solving insight problems. The results showed that only those in the spatial repetition conditions demonstrated advantages from their training, while other conditions did not show significant improvement.

3. A focus on problem-solving and cognitive strategies.

According to Mumford et al. (1991), the nature of the CPS core processes provides some useful guidelines for the design of educational interventions. Therefore, he believed that the interventions should be targeted at defining what strategies could be used to improve creative outcomes in each of these processes. Some examples of developed strategies are: defining problems in terms of solution attributes (Mumford et al., 1996), concept selection strategies in terms of (1) causes (e.g., thinking about causes that operate synergistically), (2) constraints (e.g., think about resource constraints), (3) applications (e.g., how would your solution affect multiple key stakeholders), and (4) errors (e.g., think about whether potential errors are under your control) (Peterson et al., 2013), forecasting strategy for effective implementation planning (Mumford et al., 2001), the list not exclusive.

Historically, cognitive strategy interventions primarily targeted enhancing divergent thinking. The Creative Studies Project by Osborn and Parnes laid the groundwork for extended research on influencing individuals' creative abilities. Osborn (1958) emphasized that problem orientation (or problem definition in Mumford, 1991) and ideation (idea generation in Mumford, 1991) were the most neglected steps of CPS. Hence, the Osborn-Parnes CPS approach aimed to support these cognitive processes. Techniques like problem rephrasing, brainstorming, free associations, idea checklists, self-quizzing, etc. were introduced (Osborn, 1953). This approach served as a foundation for further development of creative study programs. Some of the successful examples emerged through efforts by Noller, Parnes, and Biondi (1976), and Isaksen and Parnes (1985).

Although the Creative Study Project received positive feedback and the aforementioned strategies have been shown to improve CPS outcomes overall, their efficacy was not universal (Isaksen, 2023). Research comparing the personality features of students who dropped out of the program and those who stayed was done by Parnes and Noller in 1972. Contrary to those who stayed in the project, dropouts had lower rates of succeeding in college and tended to show higher levels of anxiety, impulsivity, and lack of focus. Isaksen (2023) mentioned a conversation with a dropout who performed exceptionally well on TTCT tests. The student told him that he had a myriad of ideas, and he did not need help with generating them. What he truly needed, however, was guidance on what to do with them.

The finding pointed to the need to balance the Osborn-Parnes CPS approach by adding guidelines and tools to foster both generating (divergent thinking) and focusing/evaluating (convergent thinking). As a result, one of the most significant advancements to modern CPS methodologies has been the shift from viewing the creative process as an order of sequential, predetermined steps to perceiving CPS as an open, dynamic process. Isaksen et al. (2000) rearranged the CPS basic processes from their original linear order into three pillars: understanding the challenge, generating ideas, and preparing for action. The clusters did not have a straight order and gave a problem solver the freedom to design their process independently. This development led to the introduction of a mindful baseline step, which they called Planning Your Approach (Isaksen et al., 2000, 2011). This step is distinct from the rest of the processes, as it implies a new self-reflective metacognitive strategy in addition to the cognitive techniques.

Ultimately, the development of cognitive studies in the late nineties shifted in CPS methodology highlighting the significance of incorporating metacognitive strategies, such as the mindful baseline step introduced by Isaksen et al., to enhance problem-solving performance, laying the groundwork for exploring the intersection between creativity and metacognition.

3. Research on Metacognition

According to Schneider (2010), research on the development of metacognition started emerging early in the 1970s by Ann Bown (Brown et al., 1983), John Flavell (Flavell et al., 2002) and their peers. The author stresses that various fields conceptualize metacognition differently. Cognitive psychology often focuses on monitoring and self-control, while social psychology and gerontology emphasize beliefs about cognitive processes rather than factual knowledge. Recent developments, however, have broadened the scope of research and included metacognition as a core facet of self-regulation (e.g., Efklides, 2001; Schunk & Zimmerman, 1998) and even cognitive neuroscience models (cf. Shimamura, 2000). Metacognition's relevance spreads across disciplines, from developmental research to motivation, clinical and educational psychology.

In cognitive development studies, the term "metacognition" has been defined as knowledge or mental activity that either takes as its object or regulates any component of any cognitive ability (Flavell et al., 2002). In other words, it entails understanding one's cognitive processes and mental states and the ability to manage them (Hacker, 1998). Therefore, most researchers identify two components of metacognition, namely knowledge of cognition and regulation of cognition (Brown, 1987; Schraw, 1998).

3.1. Understanding Metacognitive Knowledge

Metacognitive knowledge refers to the awareness of one's cognition (Schraw, 1998). According to Brown (1987), and Schraw and Moshman (1995), it consists of at least three distinct types of metacognitive knowledge: declarative, procedural, and conditional knowledge. Understanding "what" an object represents is referred to as declarative knowledge. Knowing "how" to perform something is classified as procedural knowledge. Understanding the "why" and "when" of cognitive processes is described as conditional knowledge (Schraw, 1998). In other words, declarative knowledge facilitates the identification of an object, procedural knowledge directs our approach to the use of the object, and conditional knowledge helps us comprehend the conditions and causes underlying our approach to and use of it.

Within the problem-solving framework, declarative knowledge refers to the capacity to articulate the problem. Procedural knowledge enables the selection of available problem-solving strategies, while conditional knowledge facilitates the identification of the most suitable strategies for the given problem (Urban & Urban, 2023).

3.2.Metacognitive Regulation Strategies

Hargrove & Nietfeld (2015) emphasize the importance for learners not only to comprehend their knowledge and the strategies they employ for learning but also to develop the capability to regulate this knowledge effectively. This is where the other aspect of metacognition, metacognitive regulation, is beneficial for learners. According to Schraw (1998), metacognitive regulation includes a set of abilities which help individuals in controlling their cognitive processes. Schraw and Dennison (1994) extensively discuss several component skills of regulation, including planning, information management strategies, comprehension monitoring, debugging strategies, and evaluation. However, Schraw (1998) specifically highlights planning, monitoring, and evaluating one's own performance as the core essential skills in the learning domain. Moreover, according to Efklides (2001), controlling is identified as another important regulatory skill.

Planning entails identifying the most optimal course of action, selecting the appropriate strategies, and allocating resources that have the most beneficial impact on performance (Schraw, 1998). Effective planning requires recalling and applying previous knowledge, choosing appropriate representations and methodologies, and allocating time and resources effectively (Hartman & Sternberg, 1993).

Metacognitive monitoring is defined as the evaluation of one's cognitive processes (Nelson, 1990). Monitoring involves verifying understanding of the task, memory retention of both information to be recalled and information to be retained, and assessing whether the current approach aligns with the objective, or if revision is necessary (Hartman & Sternberg, 1993). Schraw (1998) suggests that the capacity to engage in periodic self-testing during learning is an excellent example of a monitoring strategy. Control involves adjusting or modifying behavior as necessary, and it is intricately linked to the monitoring process (Efklides, 2001; Nelson, 1990).

Appraising the results and efficiency of chosen learning strategies is referred to as evaluation (Schraw,1998). Evaluation entails utilizing both internal and external feedback to guide individuals toward enhancing their future performance (Hartman & Sternberg, 1993).

According to Schraw and Dennison (1994), metacognitive knowledge of cognition and regulation of cognition are related to each other. In other words, they are not isolated skills but rather work together in a coordinated manner. He shows that the preliminary evidence suggests a $r = .50$ correlation between the knowledge about cognition and the regulation of cognition components. This indicates a strong positive relationship between the two, suggesting that individuals who possess more knowledge about cognition tend to be more effective in regulating their cognitive processes, and vice versa. For example, it was reported that college students' judgments of their ability to monitor their reading comprehension were significantly related to their observed monitoring accuracy and test performance. In another study by Schraw, Horn, Thorndike-Christ & Bruning (1995) knowledge of strategies was related to self-reported strategy use.

3.3. Instruments for Assessing Metacognitive Awareness

Different instruments have been used by researchers to assess learners' metacognitive awareness and regulation, including self-report questionnaires, coded observations, think-aloud protocols, performance ratings, and interviews (Harrison & Vallin, 2018).

Among these, self-report questionnaires have been the most broadly used tool due to their cost and time efficiency. However, self-report questionnaires are the most controversial in-class tool among metacognition researchers due to concerns about the validity of score interpretations (Harrison & Vallin, 2018). Scholars argue that respondents may introduce biases through processes like comprehending prompts, recalling events, and mapping responses to the scale (Harrison & Vallin, 2018; Jacobse & Harskamp, 2012; Tobias & Everson, 2009). Despite the potential limitations, Dinsmore et al. (2008) found that self-report questionnaires constituted 24% of the instruments used in a comparative review of 123 studies of metacognitive awareness, and the research proves their reliability and validity (Pintrich & de Groot, 1990; Ridley et al., 1992; Schraw & Dennison, 1994; Urban & Urban, 2023).

Harrison & Vallin (2018) state that among the frequently used self-report instruments are the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich & de Groot, 1990), the Learning and Study Strategies Inventory (LASSI; Weinstein et al., 1987), and the Metacognitive Awareness Inventory (MAI; Schraw & Dennison, 1994). While MSLQ and LASSI are used to measure broader learning skills, MAI was specifically designed to address knowledge of cognition and regulation of cognition by Schraw & Dennison (1994). The inventory contains 52 items, organized into eight subcomponents, which were further categorized into two main dimensions: knowledge of cognition and regulation of cognition (Schraw & Dennison, 1994).

Efforts to improve these instruments are focused on addressing construct-irrelevant variance and aligning them more closely with theoretical frameworks and specific domains. For instance, Harrison and Vallin (2018) conducted a study using confirmatory factor analysis and item-response modeling to evaluate the MAI's structure with data from 622 undergraduate students. They found support for scoring the MAI along two dimensions but identified a subset of 19 items that demonstrated a better fit to the theoretical framework than the 52-item structure, suggesting its potential for between-group comparisons and longitudinal studies.

Additionally, research focuses on assessing metacognition within specific contexts or domains. For example, Urban and Urban (2023) dedicated their efforts to introducing the Metacognition in Creative Problem-Solving (MCPS) scale. This scale adapted 11 items from the Metacognitive Self-Regulation scale of the MSLQ (Urban & Urban, 2023; Pintrich & de Groot, 1990). The MCPS underwent testing in two phases: an exploratory phase involving 350 university students and a confirmatory phase with 110 working professionals. The findings suggest that the MCPS is a reliable and valid tool for assessing metacognition in the context of creative problem-solving.

Despite criticisms and limitations, self-report measures like the MSLQ, LASSI, or MAI remain valuable for their practicality and large-scale use (Schellings & Van Hout-Wolters, 2011). They also serve as foundational tools for future refinement and adoption of more precise and efficient measurement methods, exemplified by Harrison and Vallin's (2017) identification of a 19-item subset from the MAI, or Urban and Urban's (2023) development of the MCPS scale. Self-report questionnaires are an important instrument, as an efficient assessment of metacognitive skills is required to promote their potential enhancement.

3.4.Strategies for Enhancing Metacognitive Awareness

Hartman & Sternberg (1993) offer four ways of promoting metacognitive awareness:

1. General awareness of the importance of metacognition

Despite possessing appropriate knowledge and strategies for tasks, students often fail to utilize them effectively. This can stem from a reluctance to make an extra effort due to beliefs about intellectual ability, a lack of perceived control over outcomes, or a focus on proving competence rather than improving it. Therefore, it is needed to encourage metacognitive awareness in educational contexts by talking about its significance, modelling metacognition alongside cognition, and providing time and strategies for individual and group reflection despite curricular restrictions and performance expectations (Schraw, 1994).

2. Improving knowledge of cognition

Understanding how cognition works allows individuals to optimize their learning strategies (Urban et al., 2023). One effective instrument to adopt for the improvement of knowledge of cognition in any domain was offered by Schraw (1994). The tool is referred to as a Strategy Evaluation Matrix (SEM). Each row in the SEM serves the objective of fostering clear declarative knowledge (column 1), procedural knowledge (column 2), and conditional knowledge (columns 3 and 4) on each strategy.

Additionally, comparing strategies across rows enhances one's understanding of the nuanced differences in their strategy repertoire (Schraw, 1994). One example of utilizing the SEM is to encourage learners to independently fill out each row with domain-related strategies they have learned throughout the semester and use it for planning the problem-solving approach. According to empirical studies (e.g., Jonassen et al., 2013), learning can be significantly improved by using summary matrices, like the SEM.

3. Improving regulation of cognition

By learning how to regulate one’s cognitive operations, individuals can better monitor, control, and adjust their efforts, which will enhance their learning and problem-solving performance (Urban & Urban, 2023). One method that Schraw (1994) offers to improve metacognitive regulation skills is a regulatory checklist (RC). The goal of the RC is to provide a thorough heuristic that promotes regulation. The RC presents a list of regulatory questions that help learners control their performance.

The questions offered for planning enhancement are: (1) What is the nature of the task? (2) What is my goal? (3) What kind of information and strategies do I need? (4) How much time and resources will I need?

Monitoring enhancement: (1) Do I have a clear understanding of what I am doing? (2) Does the task make sense? (3) Am I reaching my goals? (3) Do I need to make changes?

Evaluation enhancement: (1) Have I reached my goal? (2) What worked? (3) What didn’t work? (4) Would I do things differently next time?

Schraw (1994) also mentioned that a study conducted by King (1991), discovered that fifth-grade students who utilized a similar RC outperformed the control students across various variables. These included written problem-solving, the ability to pose strategic questions, and the elaboration of information. King inferred that the provision of explicit prompts, such as checklists, aided students in adopting a more strategic and systematic approach to problem-solving.

4. Fostering environments that promote metacognitive awareness.

Recent motivational theories emphasize the importance of self-efficacy, attributing success to controllable factors, and perseverance in successful students, with goal orientation being a key characteristic (Graham & Weiner, 1996; Schunk, 1989). High-mastery students, who aim to improve competence, tend to outperform performance-oriented peers by persevering, experiencing less anxiety, using more strategies, and attributing success to controllable causes (Efklides, Schwartz & Brown, 2017). Students' motivation and the adoption of mastery-approach goals were enhanced by an intervention aimed at improving metacognitive awareness (Zepeda et al., 2015). It highlights the potential benefits of emphasizing mastery goals, which can lead to a broader repertoire of strategies and enhanced metacognitive knowledge.

Knowledge of cognition and regulation of cognition are essential components of effective learning and problem-solving (Urban et al., 2023). Schraw's (1994) Strategy Evaluation Matrix (SEM) offers a practical tool for fostering clear declarative, procedural, and conditional knowledge of various strategies, while regulatory checklists (RC) provide a systematic approach for planning, monitoring, controlling, and evaluating cognitive processes. Empirical studies underscore the effectiveness of these tools in improving learning outcomes across different domains. For example, they can be beneficial when striving to enhance metacognitive awareness to improve outcomes in creative problem-solving.

4. Metacognition and Creativity

According to Scherer et al. (2012), metacognition can be considered a fundamental competency for creative problem-solving skills. Urban and Urban (2023) suggested that achieving high levels of creativity requires a certain level of metacognitive awareness. Put differently, individuals who show a lack of metacognitive skills may not exhibit high creativity. Such theorists as Cropley et al. (1998), Feldhusen and Goh (1995), Jaušovec (1994), Sternberg (1998), and Urban et al. (2021), have also posited that metacognition is intricately linked to CPS, suggesting that individuals with high levels of metacognitive awareness tend to perform better at solving creative problems.

Kaufman and Beghetto (2013) defined Creative Metacognition (CMC) as "a combination of creative self-knowledge and contextual knowledge. Creative self-knowledge refers to the ability to evaluate one's own creative strengths and limitations, both within a domain and as a general trait (Kaufman and Beghetto, 2013). In their studies, Pretz & McCollum (2014) and Silvia (2008) suggested that students with higher creative thinking skills tend to report greater accuracy in their self-assessments.

Contextual knowledge, according to Kaufman and Beghetto (2013) involves understanding the circumstances in which to apply creativity, including the when, where, how, and why of creative expression. In their research work, Urban and her colleagues (2021) examined 381 university students who completed measures of metacognitive awareness and academic motivation, along with performing four verbal creativity tasks. Non-hierarchical cluster analysis revealed two distinct groups based on metacognitive awareness: those with higher levels and those with lower levels. The group with higher metacognitive awareness levels achieved higher overall scores in creative thinking tasks, such as a product improvement task and a similarities test, compared to their counterparts.

The successful use of metacognitive regulation strategies has recently been shown to be associated with improved creative performance. For example, in their study, Cohors-Fresenborg and his colleagues (Cohors-Fresenborg et al., 2010) found that monitoring is necessary for solving ill-defined mathematical problems. Pesout and Nietfeld (2021) later showed that metacognitive monitoring accuracy is associated with more creative solutions. The findings of Gibson and Mumford (2013) suggest a strong correlation between students' ability to provide high-quality evaluations of others' creative work and their own creative performance. Specifically, when students were proficient in evaluating the creative products of others, they tended to generate more original and elegant solutions themselves. Furthermore, this enhanced evaluative ability translates into improved assessment of their own creative ideas. Similarly, Silvia (2008) discovered that individuals with higher levels of creativity demonstrated greater skill in evaluating promising ideas. It suggests a reciprocal relationship between creativity and metacognitive skill to evaluate.

Empirical evidence shows that when individuals possess metacognitive knowledge, they are better equipped to identify the essential elements of a creative idea (Urban et al., 2021). This knowledge serves as a cue in their own creative process, guiding them towards recognizing and developing innovative solutions. In essence, metacognitive awareness enables individuals to strategically leverage their understanding of creative concepts, facilitating the generation of novel and effective ideas. Hence, according to Jaušovec (1994), to enhance problem-solving abilities in educational contexts, explicit metacognitive instruction needs to be offered.

4.1.Metacognitive Interventions for CPS Enhancement

In his study, Hargrove (2013) examined the lasting impact of instructional metacognitive interventions and learning theory on students' creativity over four years of undergraduate study. Initial results showed short-term improvements in creative thinking abilities, and longitudinal analysis confirmed sustained enhancements in creativity among students who participated in these interventions. In their further research, Hargrove and Nietfeld (2015) investigated the impact of teaching creativity through divergent thinking strategies, such as brainstorming techniques, within a metacognitive framework. Thirty university design students participated in a 16-week supplemental course where creative thinking strategies were taught alongside activities to enhance metacognitive skills. Results indicated that students who received the intervention showed significantly higher scores in fluency and originality compared to their peers who did not receive the intervention. Additionally, students in the treatment group received higher ratings on a domain-specific project evaluated by external design experts.

One more important finding was illustrated by Scherer et al., (2012). After examining the problem-solving strategy knowledge and actual performance of 162 secondary students on complex chemistry problems, they stated that declarative and procedural knowledge of strategies does not guarantee success in CPS. Therefore, it is emphasized that the instructors should not only teach strategies but also focus on developing the conditional knowledge of how and when students can apply them appropriately. Particularly, providing enough practice opportunities through spaced practice sessions can help reinforce the ability to apply strategies (Son & Simon, 2012).

Additionally, it is beneficial for instructors to develop advanced metacognitive knowledge to enhance their teaching outcomes (Wilson & Bai, 2010). A successful method of metacognitive instruction involves teachers demonstrating their own cognitive processes to students while solving a problem. This can be achieved by stating their mental processes out loud as they navigate the task, thereby illustrating how to perform it. Additionally, instructors can present fix-up strategies to help students monitor and regulate their cognitive processes (Huff & Nietfeld, 2009).

Urban and his colleagues (2023) stated that effective reading strategy instruction relies on teachers' ability to foster self-regulated learning, guiding students in setting goals, utilizing strategies, and monitoring their comprehension. They emphasized that the teacher's task is to help students identify and apply suitable strategies for different contexts, enhancing their metacognitive knowledge. Successful instruction should teach active cognitive strategies, prompting students to develop, practice, and personalize the strategies they learn to enhance reading comprehension (Harris & Pressley, 1991). A study conducted by Urban et al. (2023) proves that the long-term implementation of the metacognitive strategy instruction method leads to improvements in students' strategic awareness, ultimately resulting in better reading comprehension and vocabulary outcomes by the end of the academic year.

The aforementioned findings emphasize the importance of incorporating well-structured metacognitive instruction into educational practices to empower students and improve their creative problem-solving abilities. Key factors contributing to successful interventions include offering enough practice opportunities to develop conditional knowledge, using illustrative examples of metacognitive strategies for better comprehension, and using domain-relevant examples for the explanation.

Present Study

As stated in the introduction, there is a limited amount of experimental research investigating the effects of metacognitive instruction on creative problem solving in university settings (see Hargrove & Nietfeld, 2015; Jaušovec, 1994; Urban et al., 2023). Previous studies combined the introduction of creative problem-solving enhancing strategies and metacognitive regulation strategies. Yet, the author of this research has not encountered any study focused solely on the impact of metacognitive strategy instruction on creative outcomes. Therefore, the present study aims to fill this gap by examining how metacognitive instruction, specifically teaching students strategies such as planning, monitoring, controlling, and evaluating, influences their ability to solve creative problems.

Hargrove & Nietfeld (2015) measured the effect of adding a metacognitive component to teaching CPS strategies in their study. They examined group differences in such creativity measures: similarities fluency, similarities originality, and the Remote Associates Test. The conducted repeated-measure multivariate analysis of variance found extremely strong significant effect size in the posttests (fluency, $F(118)= 81,03$, $p < .001$, $\eta_p^2 = .41$, originality, $F(118) = 131.75$, $p < .001$, $\eta_p^2 = .53$, Remote Associates Test, $F(117) = 15.20$, $p < .001$, $\eta_p^2 = .12$). All results showed significantly higher scores in the experimental group compared to the control group. Therefore, this study hypothesizes that **H1:** "Participants who received instruction in creative problem-solving processes and metacognitive strategies will generate solutions that are more original (H1a) and more useful (H1b) in the post-test task compared to participants who received instruction in creative problem-solving processes only, as well as those who did not receive any instruction." Furthermore, an understanding of one's cognitive processes is associated with improved problem-solving performance (Schraw, 1998). Hence, we expect that the group provided with an explanation of how CPS works will outperform the control group in terms of (H1c) originality and (H1d) usefulness of generated ideas. However, since knowledge of cognition alone does not necessarily enable individuals to regulate it without the application of metacognitive strategies (Cao & Nietfeld, 2005), we hypothesized that the solutions generated by the group receiving full metacognitive instruction would be more creative.

The study conducted by Tsai et al. (2018) suggests that improving learners' metacognition could enhance their interest in online learning and their commitment to Massive Open Online

Courses (MOOCs). This leads us to the **H2** of the current study: “Participants in both experimental groups, whether they received an explanation of how the creative problem-solving processes work along with instruction in metacognitive regulation strategies or only an explanation of CPS processes, will find the post-test task more interesting compared to participants who did not receive any instruction.”

Steele, McIntosh, & Higgs (2017) proposed that metacognition enhances motivation and facilitates adaptation to challenging, ill-defined tasks, thereby promoting more efficient and effective problem-solving. Hence, this study suggests that **(H3)**: “Participants in both experimental groups, whether they received an explanation of how the creative problem-solving processes work along with instruction in metacognitive regulation strategies or only an explanation of CPS processes, will find the post-test task less difficult compared to participants who did not receive any instruction.”

Given our assumption that metacognitive instruction will aid participants in perceiving problem-solving as easier, and recognizing that task difficulty serves as a cue for effort allocation, (Lauterman & Ackerman, 2019), this study assumes that (**H4):** “Participants in both experimental groups, whether they received an explanation of how the creative problem-solving processes work along with instruction in metacognitive regulation strategies or only an explanation of CPS processes, will report investing less mental effort into the generation of original solutions in the post-test task compared to participants who did not receive any instruction.”

According to the Dunning-Kruger effect (Dunning et al. 2003; Kruger & Dunning, 1999), people with limited knowledge or competence in a particular area tend to overestimate their abilities. Several studies suggest that students with higher creative thinking skills tend to report greater accuracy in their self-assessment (Grohman et al., 2006; Pesout & Nietfeld, 2021; Pretz & McCollum, 2014; Silvia, 2008), and Gibson and Mumford (2013) posit that higher levels of developed evaluation skills are associated with the production of more original and elegant creative solutions. Therefore, this study hypothesizes that (**H5):** “Participants who received instruction in creative problem-solving processes and metacognitive strategies, particularly evaluating strategy**,** will not only generate more creative solutions but will also demonstrate higher accuracy and less bias in evaluating the originality (H5a) and usefulness (H5b) of their performance in the post-test task compared to participants who received instruction in creative problem-solving processes alone or those who received no instruction.”

5. Methods

Experimental procedure

The experiment was organized with the assistance of the Laboratory of Behavioral and Linguistic Studies “LABELS,” which specializes in experimental and observational studies in psychology, linguistics, and other behavioral sciences at the Faculty of Arts, Charles University. It took place during the second week of the summer semester, in the late hours to ensure it would not conflict with students' primary course schedules. Participation in the experiment was integrated into the General Psychology and Participation in Linguistic and Psychological Experiments courses at the LABELS Laboratory (ABO700398). Participants received a part of the credit for their involvement.

One week prior to the experiment, all the registered students for these courses were sent an invitation email. It was mentioned that they would be participating in research on Creative Skills, lasting between 60 to 120 minutes and being conducted in English.

The experiment was conducted in six sessions. Each session allowed students to register, with 8 slots available for females and 8 slots for males. Therefore, the registration set-up provided equal gender distribution for each session.

Every session was randomly assigned to one of the following conditions:

1. Experimental group with Creative Problem-Solving and Metacognitive Strategies Instruction (2 sessions).
2. Experimental group with Creative Problem-Solving Instruction (2 sessions).
3. Control group (2 sessions).

All participants were Czech students; therefore, each was asked to confirm their ability to comprehend and participate in the experiment conducted in English. All participants confirmed their ability, which is why no exclusions were necessary.

The sessions took place in a spacious room with seats arranged in a half-circle to facilitate group communication among all participants. Each participant was tasked with completing a pre-test questionnaire, which included a CPS task, and measures of self-evaluation.

After administering the questionnaire, the instructional phase commenced. The first experimental group received guidance on creative problem-solving and metacognitive strategies, emphasizing their application to creative problem-solving. The instruction consisted of two main components: an explanation of creative problem-solving processes and an introduction to metacognitive regulation strategies. Firstly, students were explained such concepts as creativity, creative problem-solving, and the core processes of CPS, utilizing Mumford's (1991; 2019) framework. After that, they were acquainted with the concepts of metacognition, metacognitive knowledge, and metacognitive regulation strategies, including planning, monitoring, controlling, and evaluating strategies.

Unlike previous research, which often combined creative problem-solving and metacognitive strategies, this study focused solely on the impact of metacognitive strategy instruction on creative outcomes. Specifically, the instruction targeted planning, monitoring, controlling, and evaluating cognitive processes in CPS exercises. Such tools as SEM and RC (Schraw, 1994) were introduced to help students improve their metacognitive awareness.

The successful intervention factors outlined by Hargrove and Nietfeld (2015), such as meaningful tasks, and focus on cognitive processes were incorporated. Moreover, the research ensured the incorporation of key elements for effective metacognition instruction, including practice opportunities to develop conditional knowledge, and illustrative examples of metacognitive strategies for better comprehension.

The second experimental group received solely the explanation of concepts such as creativity, creative problem-solving, and the core processes of CPS, utilizing Mumford's (1991; 2019) framework on creative problem-solving processes, while the control group watched a 20-minute video titled "Funny Farm Animals." The video covered neither creative problem-solving nor metacognition.

After the intervention, each participant completed a post-test questionnaire, which included the CPS task and assessments of self-evaluation. In both pre-and post-tests, students were permitted to use any resources they found effective for generating the most original solutions, including the internet, ChatGPT, or conversations with each other.

The whole experiment took M_{time} = 110 (*SD* = 10) minutes in the first experimental condition (creative problem-solving + metacognitive strategy instruction), M_{time} = 85 (*SD* = 5) in the second experimental condition (creative problem-solving instruction), and M_{time} = 60 minutes (*SD* = 5) in the control condition.

Participants

To ensure the validity of the present study, the a priori sample size was calculated using G*Power 3.1.9.7, $\alpha = .05$, $\beta = .80$, with an effect size $\eta_p^2 = .57$. The expected effect size was calculated from the between-group differences in Hargrove & Nietfeld (2015). The minimum required number of participants was 8 participants for each group. However, given the limitations of parametrical statistical tests, we decided to increase the number of participants.

In the first control group of this study, there were 29 participants, split between 14 males and 15 females. The second experimental group included 22 participants, with 14 females and 8 males. The control group consisted of 28 participants, with an equal distribution of 14 females and 14 males. All participants were at the undergraduate (BA) level, with two individuals studying General Psychology and the remaining students coming from various faculties, enrolled in Participation in Linguistic and Psychological Experiments courses at the LABELS Laboratory. The sample was homogenous in terms of race and ethnicity.

Measures

Creative problem solving. Prior to and after the experiment, participants were presented with a complex ill-defined problem-solving task known as the Product Improvement Task (PIT). The original PIT, as proposed by Torrance (1974), asks participants to come up with ways to enhance a product, such as a common toy, chair, or table. Two options with more complex scenarios were used in this research.

The first version, adapted from Urban et al. (2023), introduced the following scenario:

Mattel is an American toy manufacturer. In terms of sales, it is the second largest toy manufacturer in the world, right after the Lego Group. However, Mattel's goal for this year is to become the largest toy manufacturer in the world.

Imagine you have been hired by Mattel as a consultant. Your first task is to come up with three ideas to improve an ordinary stuffed bunny, about 30 cm in size, to make it more fun to play with. How can the bunny be improved so Mattel's sales are higher than the Lego Group?

The second option was proposed by the author of this research and introduced the following scenario:

Costa Coffee is a well-known coffeehouse chain, currently ranking second in coffee sales in Czechia, just behind Starbucks'. Costa Coffee aims to become the top-selling coffee brand this year.

Picture yourself as a consultant for Costa Coffee, and your initial assignment is to create three innovative ways to improve a standard reusable coffee mug to make it more attractive and increase Costa's sales to surpass Starbucks'.

You are asked to create three solutions that are both as original and as useful as possible to help Costa Coffee in its mission.

To ensure balance in the difficulty levels between the two versions of the PIT, the task versions were exchanged for each session. Therefore, half of the participants in each group undertook the first option as a pre-test task, followed by the second version as a post-test task, while the other half completed the tasks in reverse order.

Two experts conducted blind and independent evaluations of the responses, which were presented in a randomized order. The evaluations were based on two primary components of creativity: originality and usefulness, as defined by Mumford and Gustafson (1988). Originality stands for the novelty and uniqueness of the solution, while usefulness relates to the practical value of the solution (e.g., its ability to increase sales for Costa Coffee). Each dimension was assessed using a scale ranging from 1 (worst) to 5 (best). The inter-rater agreement was perfect for each evaluated component (weighted $\kappa_{originality} = .92$, $\kappa_{usefulness} = .85$).

Self-evaluation. After each provided answer to PIT, participants were asked to evaluate their solutions based on two criteria: quality and originality (Rominger et al., 2022). In line with the methodology of Beghetto & Karwowski (2017), Karwowski et al. (2019), outlined in Urban et al. (2023), the instructions for self-evaluation were as follows: "On a scale of 1 to 100, indicate how useful you think your improvement is," and "On a scale of 1 to 100, indicate how original you think your improvement is."

Perceived task interest. Following completion of the task, all participants were asked to assess their level of interest in task resolution by responding to the question “How interesting was it to solve this task?” utilizing a rating scale from 1 (indicating minimal interest) to 100 (indicating maximal interest) (Urban et al., 2023).

Perceived task difficulty. Following completion of the task, all participants were asked to evaluate the difficulty of the resolution by responding to the question “How difficult was it to solve this task?” utilizing a rating scale from 1 (indicating minimal difficulty level) to 100 (indicating maximal difficulty level) (Urban et al., 2023).

Perceived mental effort. Following completion of the task, all participants were asked to evaluate the invested mental effort in resolving the task by responding to the question “How much mental effort did you invest in solving this task?” utilizing a rating scale from 1 (minimal effort) to 100 (maximal effort) (Urban et al., 2023).

6. Results

The Results section examines whether metacognitive instruction enhances the generation of more original (H1a) and more useful (H1b) solutions to ill-defined tasks, whether it increases interest in the task (H2), whether it reduces the perceived difficulty of the task (H3), whether it requires less mental effort investment (H4), and whether it facilitates more accurate self-evaluation and reduces bias (H5).

Table 1

Descriptive statistics and basic comparison of individual variables for the control and experimental groups

		Pre-test		Post-test		*t*	*p*	*d*
		M	*SD*	*M*	*SD*			
PIT (originality)	1. Control	2.75	1.08	2.57	0.99	0.67	.502	0.18
	2. Experimental CPS	2.41	0.95	2.71	1.01	-1.03	.307	-0.31
	3. Experimental CPS + MC	2.22	1.11	2.34	1.03	-0.43	.67	-0.11
PIT (usefulness)	1. Control	3.01	0.93	2.78	0.84	0.94	.35	0.25
	2. Experimental CPS	2.73	0.94	2.84	1.01	-0.38	.702	-0.11
	3. Experimental CPS + MC	2.49	0.92	2.63	0.15	-0.60	.553	-0.16
Bias (originality)	1. Control	-0.05	0.29	0.06	0.32	-1.40	.168	-0.37
	2. Experimental CPS	-0.00	0.22	0.03	0.27	-0.45	.652	-0.13
	3. Experimental CPS + MC	0.02	0.21	0.05	0.20	-0.72	.475	-0.19
Bias (usefulness)	1. Control	0.10	0.26	0.08	0.30	0.07	.947	0.02
	2. Experimental CPS	0.08	0.26	0.19	0.20	-1.56	.126	-0.47
	3. Experimental CPS + MC	0.15	0.20	0.14	0.22	0.12	.907	0.03
Perceived Interest	1. Control	6.03	1.93	5.93	1.90	0.21	.835	0.05
	2. Experimental CPS	5.82	2.11	6.63	1.56	-1.46	.151	-0.44
	3. Experimental CPS + MC	6.70	1.63	6.58	1.47	0.25	.801	0.06
Perceived Difficulty	1. Control	4.78	2.21	4.71	1.82	0.13	.896	0.03
	2. Experimental CPS	5.31	1.88	4.27	1.91	1.83	.075	0.55
	3. Experimental CPS + MC	4.96	1.84	4.14	2.12	1.59	.118	0.42
Invested Mental Effort	1. Control	5.18	1.74	5.25	1.92	-0.14	.885	-0.04
	2. Experimental CPS	5.91	1.57	5.41	1.73	1.00	.322	0.30
	3. Experimental CPS + MC	5.96	1.99	6	1.67	-0.07	.943	-0.02

Table 1 presents the descriptive statistics for the control group and both experimental groups, along with the results of independent-sample t-tests. Subsequent hypothesis testing utilized ANOVAs to compare the pre- and post-test result.

Metacognitive instruction enhances the generation of more original (H1a) and more useful (H1b) solutions to ill-defined tasks

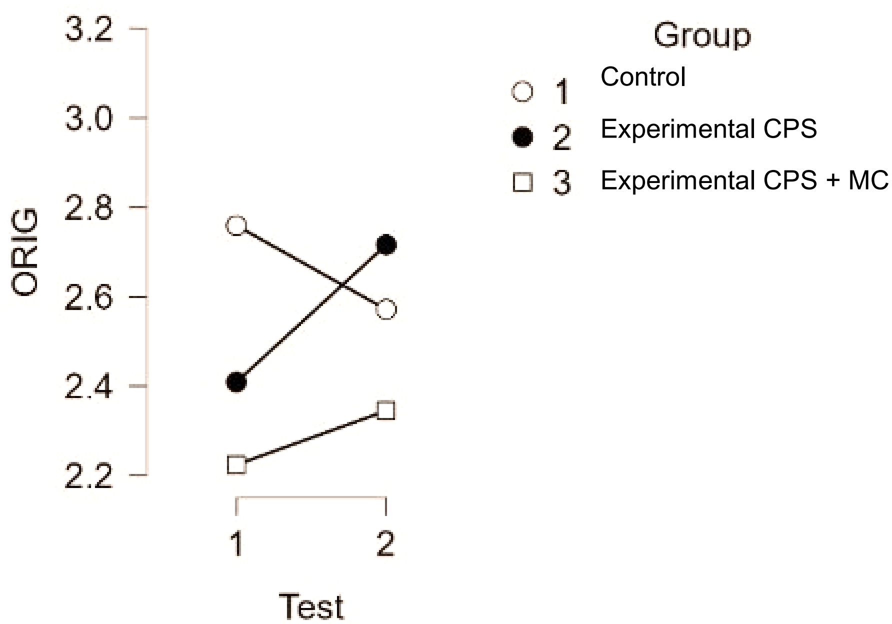
An ANOVA was conducted to evaluate the impact of metacognitive instruction on originality and usefulness of creative solutions. The analysis revealed no statistically significant difference in originality between pre-test and post-test results, $F(1, 152) = 0.23$, $p = .631$, $\eta^2 = .00$. Moreover, no significant difference was found between groups, $F(2, 152) = 2.04$, $p = .133$, $\eta^2 = .03$. Finally, there was no significant interaction between groups and pre- and post-test results, F(2,

152) = 0.74, p = .481, η^2 = .01, meaning that the development between pre- and post-test was similar in each of the groups.

Although no statistical significance was found, there is a discernible trend towards improvement in the originality of post-test solutions within both experimental groups, as depicted in Figure 1. However, these trends may not be readily apparent due to the small sample size.

Figure 1

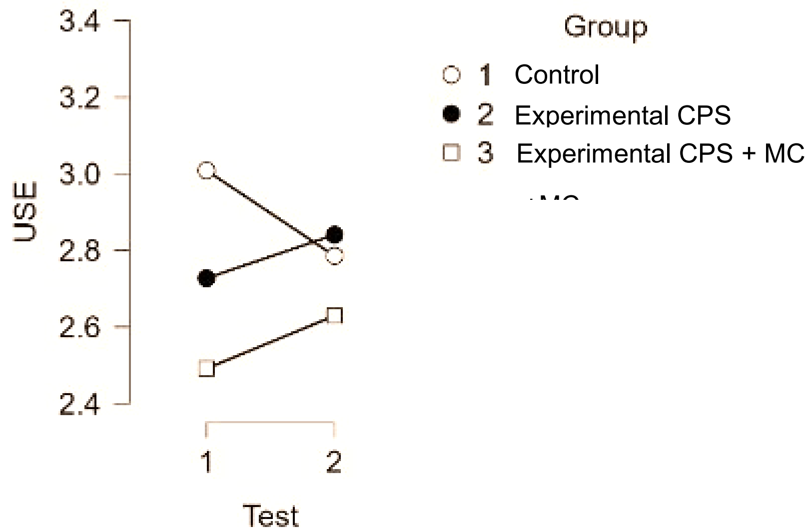
The originality of solutions in pre-test and post-test task



In terms of the usefulness of solutions, similar results were observed as depicted in Figure 2. A trend to improvements in the post-test outcomes is seen in both experimental groups, yet no statistically significant effect size was identified. ANOVA revealed no difference between pre-test and post-test results, $F(1, 152) = 0.00$, p = .948, and η^2 = .00. Similarly, no difference was found between groups, $F(2, 152) = 2.02$, p = .136, and η^2 = .02. Moreover, there was no interaction observed between groups and the pre- and post-test outcomes, $F(2, 152) = 0.55$, p = .511, and η^2 = .00.

Figure 2

The usefulness of solutions in pre-test and post-test task

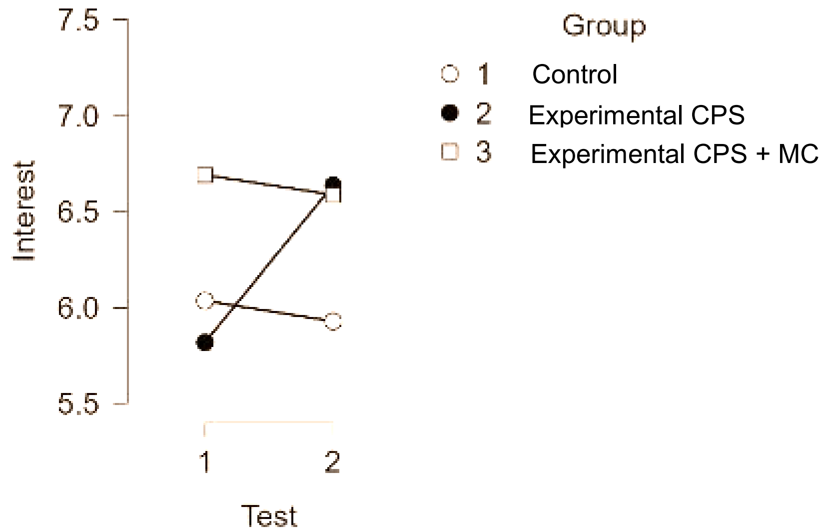


Metacognitive instruction increases interest in the task (H2)

The analysis of self-reported perceived interest in the pre-test and post-test revealed no significant difference between pre-test and post-test results, $F(1, 152) = 0.50$, $p = .478$, and $\eta^2 = .00$. Similarly, no difference was found between groups, $F(2, 152) = 1.98$, $p = .141$, and $\eta^2 = .02$. Furthermore, there was no interaction observed between groups and the pre- and post-test outcomes, $F(2, 152) = 1.07$, $p = .344$, and $\eta^2 = .01$. However, as it is noticeable in Figure 3, the group solely receiving an explanation of creative problem-solving processes perceived the post-test task as more interesting. In contrast, neither the group additionally introduced to metacognitive regulation strategies nor the control group reported increased interest.

Figure 3

Perceived interest in the pre-test and post-test task



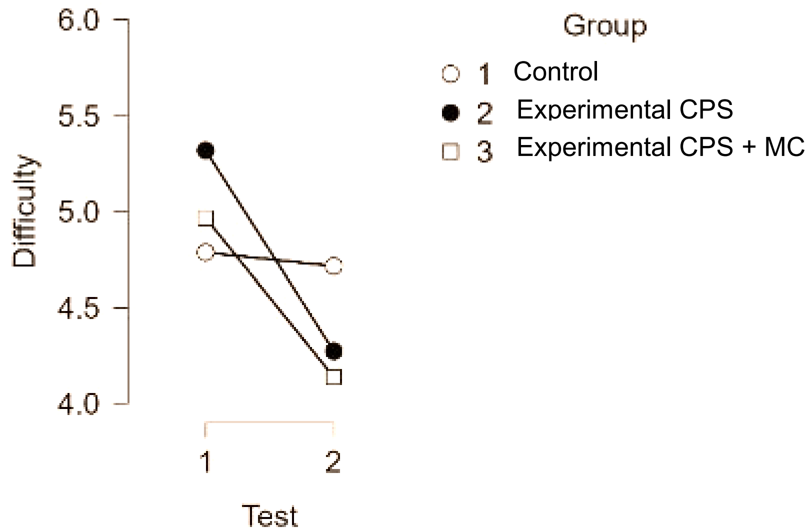
Metacognitive instruction reduces the perceived difficulty of the task (H3)

The findings revealed a significant difference in the perceived difficulty level in pre-test and post-test results, albeit with a small effect size, $F(1, 152) = 4.18$, $p = .043$, and $\eta^2 = .02$. No significant differences were observed between the groups, $F(2, 152) = 0.23$, $p = .795$, and $\eta^2 = .00$, nor was there a significant interaction between groups and the pre- and post-test outcomes, $F(2, 152) = 0.87$, $p = .419$, and $\eta^2 = .01$.

Nevertheless, a clear trend is seen indicating that both experimental groups perceived the post-test task as easier compared to the pre-test task (as depicted in Figure 4). However, this trend lacks statistical probably due to the limited sample size.

Figure 4

Perceived difficulty in the pre-test and post-test task



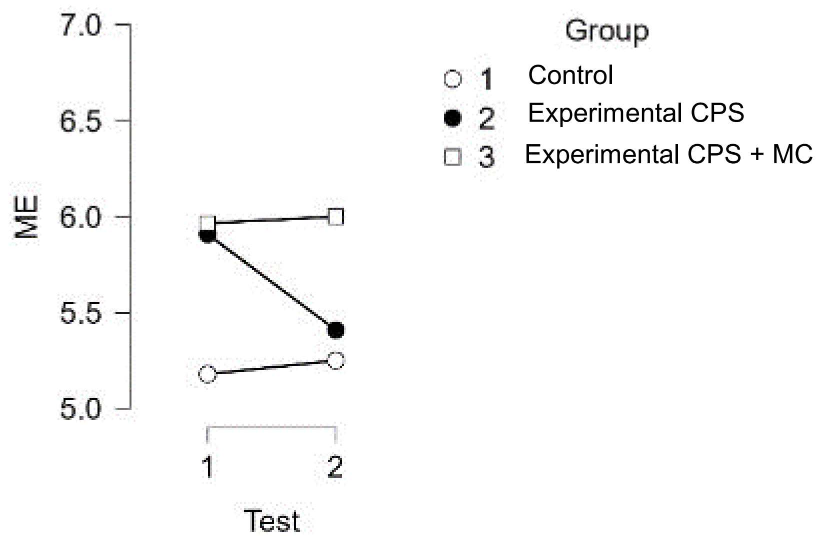
Metacognitive instruction requires less mental effort investment (H4)

The results indicated no significant difference in invested mental effort between pre-test and post-test, $F(1, 152) = 0.21$, $p = .647$, and $\eta^2 = .00$. Neither difference was found between groups, $F(2, 152) = 2.65$, $p = .07$, and $\eta^2 = .03$. Furthermore, there was no interaction observed between groups and the pre- and post-test outcomes, $F(2, 152) = 0.381$, $p = .684$, and $\eta^2 = .00$.

It can be noticed in Figure 5 that only the group instructed on creative problem-solving processes reported a decrease in mental effort when solving the post-test task compared to the pre-test task. No difference was observed in the control group, or the group additionally introduced to metacognitive regulation strategies.

Figure 5

Perceived mental effort invested in the pre-test and post-test

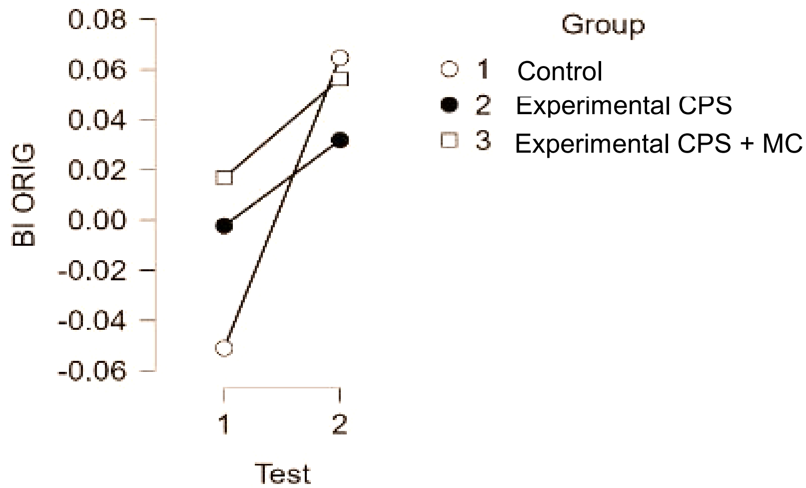


Metacognitive instruction facilitates more accurate self-evaluation and reduces bias (H5)

The examination of participants' self-evaluation regarding the originality of their solutions unveiled no statistically significant distinction between pre-test and post-test outcomes, $F(1, 152) = 2.30$, $p = .131$, $\eta^2 = .01$. Moreover, no significant difference was found between groups, $F(2, 152) = 0.20$, $p = .819$, $\eta^2 = .00$. Finally, there was no significant interaction between groups and pre- and post-test results, $F(2,152) = 0.41$, $p = .659$, $\eta^2 = .00$. The results show that all participants in this study exhibited a slight increase in bias when judging the originality of their solutions. However, the control group showed the largest increase in bias, while both experimental groups exhibited almost no rise in their bias (as depicted in Figure 6).

Figure 6

The bias in evaluating the originality of one's solution in the pre-test and post-test tasks

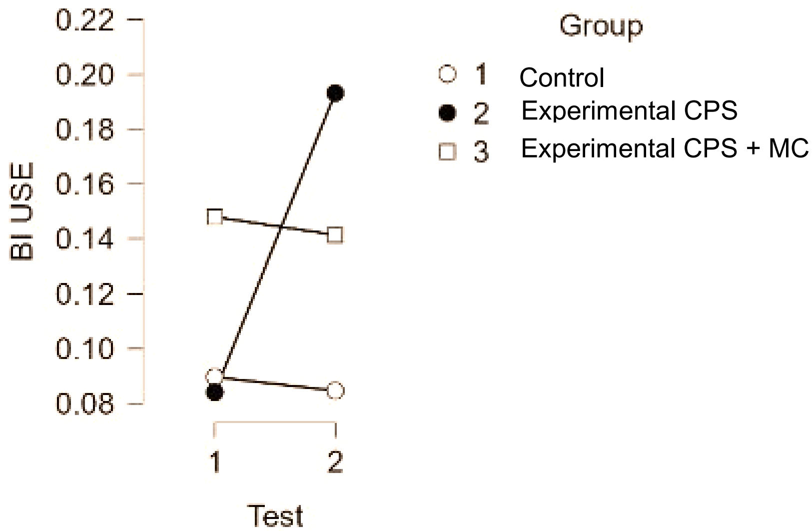


Concerning bias towards the usefulness of their solutions, the results were similarly not statistically significant. No significant difference in usefulness bias was indicated between pre-test and post-test, $F(1, 152) = 0.69$, $p = .405$, and $\eta^2 = .00$. Neither difference was found between groups, $F(2, 152) = 0.93$, $p = .396$, and $\eta^2 = .01$. Furthermore, there was no interaction observed between groups and the pre- and post-test outcomes, $F(2, 152) = 0.88$, $p = .413$, and $\eta^2 = .01$.

It can be noted that neither the control group nor the group that received full metacognitive instruction exhibited differences between pre-test and post-test judgment. Yet the group with only an explanation of creative problem-solving processes showed a higher bias in the post-test compared to the pre-test (see Figure 7).

Figure 7

The bias in evaluating the usefulness of one's solution in the pre-test and post-test tasks



7. Discussion

The goal of this study was to investigate how knowledge about one's cognitive processes and application of cognition regulation strategies such as planning, monitoring, controlling, and evaluating, influence the ability to solve creative problems. We used the modification of the Product Improvement Task (Torrance, 1974) to stimulate the creative problem-solving process in generating novel and socially valued ideas, that would potentially help increase sales of the product (Urban et al., 2023).

The findings of the current study revealed a small effect size of the instruction within both experimental groups, which did not reach statistical significance. Hence, while the interventions may have had some effect, we cannot conclusively affirm it. Notably, a slight impact of the intervention was observed in both experimental groups, leading to the generation of more original and practical solutions in the post-test. This observation aligns with the expectations (Hargrove & Nietfeld, 2015; Urban & Urban, 2023). Furthermore, as anticipated (Steele et al., 2017), both experimental groups perceived the post-test task to be slightly less difficult compared to the pre-test task.

Interestingly, only the group instructed on creative problem-solving processes reported a significant decrease in invested mental effort when solving the post-test task compared to the pre-test task. Despite the expectations (Lauterman & Ackerman, 2019), the group which additionally was instructed with metacognitive regulation strategies did not report this change. It has been observed during the sessions that there were differences in student engagement and comprehension levels when they were taught about the processes of creative problem-solving and instructed on how to apply metacognitive regulation strategies. The instructor's subjective observations suggest that a majority of participants faced difficulty in fully developing the procedural and conditional knowledge of the regulation strategies and applying them immediately to solve the PIT in the post-test. This can be explained by the assumption that the metacognitive strategy instruction might have imposed an additional extraneous cognitive load (Merrienboer & Sweller, 2005) on the participants, affecting the perception of the task as requiring more mental effort. Yet, this assessment needs to be tested by conducting further research.

Taken together, the observations from this study suggest that metacognitive knowledge and regulation strategies instruction may be beneficial for creative problem-solving performance and self-evaluation abilities. However, the limitations of this study need to be taken into consideration and further refined experimental research needs to be conducted to strengthen the validity of the findings.

7.1. Limitations and further research directions

One important concern of the experiment was the inability to conduct an extended, multi-session study. The experiment was confined to a single session for each group, lasting an average of 87 minutes. Although Bernacki et al. (2020) observed a significant impact of a single 2-hour metacognitive strategy instruction on overall performance in STEM coursework, Hargrove & Nietfeld (2015) point out that distributed training sessions over a period of time are essential for developing conditional knowledge about the regulation strategies. Similarly, Schraw (1994) emphasizes that having descriptive knowledge of a strategy does not necessarily equate to understanding when, where, and how to apply it effectively. Despite our research indicating a trend for an increase in the originality and usefulness of generated solutions following metacognitive strategy instruction, the observed improvement did not reach statistical significance. This lack of significance may be attributed to the insufficient practice of the strategy. Therefore, further studies should focus on assessing the impact of metacognitive interventions in multi-session studies, allowing for spaced repetition, and placing more emphasis on building a practical understanding of the individual application of metacognitive strategies.

Furthermore, the instructional approach to metacognitive regulation strategies introduced two key tools in the present study – the Strategy Evaluation Matrix and Regulatory Checklist (Schraw, 1994). Extending the intervention period is crucial not just for mastering the use of these tools and gaining confidence but also for potentially introducing supplementary self-regulatory tools like journal keeping, which aids in performance reflection and fosters the development of self-assessment skills (Hargrove & Nietfeld, 2015).

Expanding and elaborating on the study curriculum for learning self-regulation skills could involve refining the strategy use in more domain-specific tasks relevant to the participants. Although the present study emphasized the intervention's relevance to each participant's field of study and interests through engaging discussions and relevant examples, the tasks for practicing problem-solving performance during the experiment were solely domain-general, which is another limitation of short intervention settings. Baer (2012), for example, argues that creativity is highly domain-specific and that domain-general skills or traits contribute little to creative performance. Therefore, a potential study curriculum for further research would need to take this consideration into account and focus on incorporating more education and interest domain-relevant tasks into the curriculum. This adjustment could potentially not only improve creative outcomes (Baer, 2012) but also increase levels of intrinsic motivation and, consequently, perceived interest in metacognitive awareness improvement (Sternberg & Kaufman, 2010).

Given the opportunity for extended cognitive processes regulation instruction, greater emphasis should be placed on the individual approach to self-regulation. It is possible to introduce and expand upon the baseline "Planning your Approach" step proposed by Isaksen (2023) as a metacognitive regulation step. This approach would disrupt the linear understanding of creative problem-solving models (Mumford, 1991) and assist students in identifying the most effective self-regulated approach for approaching ill-defined tasks.

Another concern regarding the results is the assessment of creative problem-solving abilities through a single experimental task, i.e., a task lacking ecological validity. While the Product Improvement Task (PIT) is a commonly used measure in experimental settings to assess individual creative problem-solving potential (Urban et al., 2023), future research could explore ill-defined tasks that better reflect real-world challenges in university settings. For instance, tasks such as essay writing or presentation preparation (Jonassen, 2011) could be considered for their ecological validity.

Additionally, the indication of trends in the data, without reaching statistical significance, may signal limitations in the sample size (Marshall et al., 2013). Single sample size calculation was derived from an intervention study published by Hargrove & Nietfeld (2015), which reported significant effects. However, these effects were notably large due to the essence of the intervention conducted by the authors, leading to an underestimation of the expected sample sizes required to sufficiently power our study to detect the effects observed here. Therefore, the sample size was not optimal for the current study and would require expansion to enhance the statistical significance of the findings.

7.2. Conclusions

The existing body of research suggests that metacognition plays a significant role in developing creative problem-solving skills (Scherer et al., 2012). Urban and Urban (2023) argue that attaining high levels of creativity requires a high level of metacognitive awareness. Numerous studies have established correlations between metacognitive awareness and various facets of creative problem-solving (Cropley et al., 1998; Hargrove & Nietfeld, 2015; Jaušovec, 1994; Urban et al., 2021). In line with previous studies, our research indicates that educating individuals on the cognitive processes of creative problem-solving and providing instruction on metacognitive regulation strategies may affect CPS outcomes. However, the data collected in this study are not conclusive enough to prove this assertion. Therefore, our study underscores the need for further exploration and refinement of metacognitive interventions in creative problem-solving research.

As Isaksen (2023, p. 18) states, “The complete story of CPS has yet to be written. Contemporary CPS has deep theoretical foundations, robust empirical research, and powerful practical applications for it.” This points to the importance of addressing identified limitations and conducting more extensive research with larger sample sizes, multi-session studies, and diverse assessment tools to continue writing the empirical story of CPS. By integrating insights from our study, future research can develop comprehensive interventions that enhance individuals' metacognitive awareness to improve creative problem-solving outcomes. This ongoing research trajectory will inform educational practices and professional training programs aimed at inhancing creativity and innovation across various domains.

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