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EFFECT OF SELF-REGULATION ON CREATIVE THINKING SKILLS OF PHYSICS STUDENTS AT SECONDARY LEVEL

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Abstract
The aim of the study was to determine the effect of self-regulation on creative thinking skills of physics students at secondary level. Education serves as an important part in development of valuable human resources. It needs to be focused on developing adaptable, productive and responsible human resources by incorporating life skills into learning if it is to thrive and compete worldwide in the twenty-first century. Physics is an important part of everyday life and involves problem solving. As the world is developing, students need to develop creative skills to face developed world. Self-regulation serves as an important mode in developing creative skills because it helps to develop motivation for establishing goals and works with dedication to achieve them. Creative thinking helps to identify problems and find solutions. Quantitative research was carried and female students were selected for the study. The results demonstrated that majority of the students regulated their goals, behaviors, and was confident about themselves. The findings revealed that more than half of the participants showed better creative thinking skills in comparison to others. Data retrieved from the questionnaire and test suggests strong relationship between self-regulation and creative thinking skills of physics students at secondary level.
Key words: Problem solving; Creative skills; Self-regulation; Motivation; Dedication

INTRODUCTION

Education serves as an important part in development of valuable human resources. A country's standard of living will be assessed by quality of its human resources. For a nation to keep pace with the developed world, quality education is an important element. Education needs to be focused on developing adaptable, productive and responsible human resources through the incorporation of life skills into learning if it is to thrive and compete worldwide in the twenty-first century. Students need to exhibit creative thinking abilities as one of their lifelong skills. Lives of current student generation differs from the lives of previous generations due to rapid advancement of science and technology. Current generation student facing a lot of challenges due to competition. Therefore, it's necessary to develop adaptive and unique strategies to face future challenges and competes successfully (Andrini, 2016).

Creativity is a crucial skill for students, as it enables innovative solutions and contributes to science advancement, future work and economic development. It is essential for human adaptability and societal performance. Therefore, it should be a priority in education, focusing

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on critical thinking, creativity, collaboration and communication skills. Creativity generates new ideas and innovations allowing innovators to face life more effectively. These skills can be taught in simple, different, unique and beneficial ways. Developing students' creativity is not a necessity, but rather a necessary skill for success in the 21st century (Runco, 2017).

Creativity comprises of flexible, fluent, distinctive thinking in different situations. Authenticity means of delivering unique responses, flexibility defined as capacity of adapting to changing conditions and fluency as quick sequencing of ideas (Duff et al., 2013). According to Sternberg and Lubart (1996), being able to come up with genuine solutions to problems is what is meant by the term creativity. Beyond starting from scratch, creativity frequently involves refining an existing idea or concept or combining ideas that have been known or owned in the past to create something new. Creative thinking is therefore characterized by the synthesis and redefinition of prior ideas.

The process of creative thought has four distinct stages, which are preparation, incubation, illumination, and verification. Creative expression and intellectual capacity have historically been viewed as distinct from one another, especially in the field of artistic creation. Since there are few possibilities for people to exhibit creative qualities when there are no issues to address, creative people are attentive to the presence of problems. Imagination, exposure to new interactions, curiosity, intuition, and idea creation, tolerance for uncertainties, independence, invention, enlightenment illumination, and visualization are just a few of the many essential characteristics of innovation that Wu et al. (2014) highlighted. Another aspect of creativity involves the use of imagination and critical thinking skills (Feldhusen and Goh, 1995).

Similarly, active participation in learning during class is necessary for the development of creative thinking skills. Self-regulation also serves as important element in creative thinking. The potential to control one's internal reactions i.e. emotions, thoughts and habits in order to accomplish objectives and engage in social relationships is known as self-regulation. Metacognition, an important component of self-regulation helps students in regulating and monitoring their acts during academic work (Algiani et al., 2023).

The capacity to comprehend and manage one's learning environment is known as self-regulated learning. Setting goals, keeping track of oneself, learning how to control oneself and receiving feedback from oneself are ways to demonstrate self-regulation skills (Schraw et al., 2006). Self-regulation is not the same as mental aptitude or academic accomplishment. Instead, self-regulation is a self-directive process and behavior set that learners adopt as a result of receiving responses and supervised practice, enabling them to convert their mental capacities into skills and habits (Butler, 2002). Self-control, task analysis, goal planning and the ability to choose, modify or create new techniques to accomplish goals are all characteristics of effective learners. Along with keeping an eye on their progress, these learners also manage distracting thoughts and low motivation while modifying their success-promoting tactics. These are the young pupils who schedule time, take records and pose questions that help them to be in charge of their own learning (Dong et al., 2022).

In order to transmit skills and information and promote lifelong learning, self-regulators must cultivate effective learning techniques, effort and perseverance. Self-regulated learning practices are highlighted in this information sheet, which offers instructional tactics for adult education settings. In their search of knowledge and targets attainment, self-regulated students exhibit metacognitive, motivational, and behavioral activity. After Bandura's subsequent publications on self-efficacy, motivation became recognized as another regulatory domain, complementing the behavioral and emotional control that self-regulation first focused on (Bandura, 1982). A purposeful process including developed ideas, emotions and attitudes

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focused on reaching objectives, learning is seen as such. All students need these skills and instructors need to know how to help them develop (Zimmerman, 2001).

Research Objectives

- To explore student's self-regulation in physics at secondary level.
- To measure student's creative thinking skills at secondary level.

Research Questions

Specifically, the research seeks to address the following questions:

1. To what extent does self-regulation impacts the creative thinking abilities of secondary level physics students?
2. How do various aspects of self-regulation, such as goal-setting, time management, and self-monitoring, relate to creative thinking skills in the context of physics education?
3. What strategies can be implemented to enhance self-regulation and foster creative thinking skills among secondary level physics students?

Significance of Research

Research on the impact of self-regulation on the creative thinking skills of secondary-level physics students holds significant value for improving science education. Physics learning goes beyond recalling formulas and concepts; it requires students to think originally, design inventive solutions, and approach problems from multiple perspectives. Creative thinking is therefore essential for helping learners move past rote memorization and engage in deeper scientific inquiry. Self-regulation through goal setting, strategic planning, progress monitoring, and reflective thinking supports this process by enabling students to manage their cognitive resources effectively, sustain motivation, and adapt their strategies when confronted with challenging tasks. Understanding how these self-regulatory practices influence creativity can provide educators with meaningful insights for developing students who are more independent, reflective, and innovative. Ultimately, this line of research has the potential to inform curriculum development, strengthen scientific competence, enhance overall academic performance, and better equip students with the adaptable and imaginative thinking skills required in the 21st century.

Theoretical Framework

The theoretical framework for investigating the influence of self-regulation on the creative thinking skills of secondary-level physics students draws primarily from three foundational perspectives i.e., Self-Regulated Learning Theory, Metacognition Theory, and Creativity and Divergent Thinking Theory. Collectively, these theories explain how students' ability to manage and direct their own learning can strengthen their creativity in physics-related tasks, including problem-solving and scientific inquiry.

Theoretical proposition drawing from these interconnected theoretical foundations, the study proposes that students with higher levels of self-regulation are more likely to exhibit strong creative thinking skills in physics, as they are better equipped to manage their cognitive processes, sustain motivation, consider alternative solutions, and reflect effectively on their learning experience.

The study aims to explore the correlation between self-regulation strategies and the development of creative thinking abilities in the context of physics education. Students regulating their own learning processes and the influence of their creative problem-solving skills in physics, the study seeks to contribute to a deeper understanding of effective teaching and learning strategies in science education. Through research and data analysis, the study provide insights into the potential benefits of promoting self-regulation techniques as a means

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to enhance students' creative thinking skills, ultimately informing educators and policymakers about effective instructional approaches in physics education.

LITERATURE REVIEW

The development of priceless human resources and the preservation of a nation's level of living depend heavily on education. The development of flexible, accountable, and productive human resources via life skills is the primary priority for nations in the twenty-first century. Since science and technology are advancing at a rapid pace, students must demonstrate their ability to think creatively as a lifelong talent. In addition to improving students' meditation abilities, the thinking process attempts to equip them for organizing, observing, and assessing mental processes. Developed nations have focused on helping kids think more critically so they can meet the difficulties and changes of modern life. Students can compete in a world that is changing quickly if they can learn to think critically and analyze, evaluate and criticize (Al-Zuabi, 2014). A modern educational challenge is creating teaching methods and curricula that offer specific learning capabilities. This calls for efforts to train teachers and encourage them to use these curricula. Self-regulated learning has grown to be a prominent area of study since it stresses students' freedom in their education (Baars et al., 2018).

The growing emphasis on self-regulation in educational settings gave rise to the phrase self-regulated learning process (Dinsmore et al., 2008). During this period, learners were requested to self-report how well they performed in reaching certain goals, such as finishing a given amount of arithmetic homework problems. Pupils who gave themselves clear, attainable goals had higher levels of accomplishment and self-efficacy beliefs. It's interesting to note that "spontaneous" increases in functioning were frequently observed when students were merely asked to self-record some aspects of their learning, including finishing projects. These results, which the scientific literature refers to as "reactivity," suggested that students' self-awareness of certain parts of their functioning, or metacognitive awareness, might improve their self-control. Naturally, when a student doesn't possess foundational skills, self-awareness is frequently inadequate but it can still result in a preparedness that is necessary for personal transformation (Zimmerman and Schunk, 2001).

Self-regulation entails managing one's thoughts, feelings, impulses and productivity. It includes creating ideas and behaviors to achieve goals as well as halting or restricting activities. Setting aims, monitoring one, training and reinforcement are all part of this self-directive procedure that turns mental aptitudes into educational talents (Zimmerman, 2000).

In educational research, the cycle model of SRL is frequently employed. It separates the three stages of pupil learning i.e., Forethought phase, Performance phase, and Self-reflection phase. By using reading methods before, during and after reading, children may self-regulate their reading process, according to this model. Students may establish reading objectives, assess the importance of the reading assignment or express how tough they believe the job to be during the forethought phase. Students may use reading methods, keep an eye on their own reading or ask for assistance throughout the performance phase. Students can assess their own studying process in a variety of ways within the self-reflection phase and choose to go on to the next forethought step. Every stage includes motivational and metacognitive processes (Panadero, 2017).

The subcomponents of self-regulated learning are depicted in Figure 1 can be further separated from the three main parts of self-regulation.

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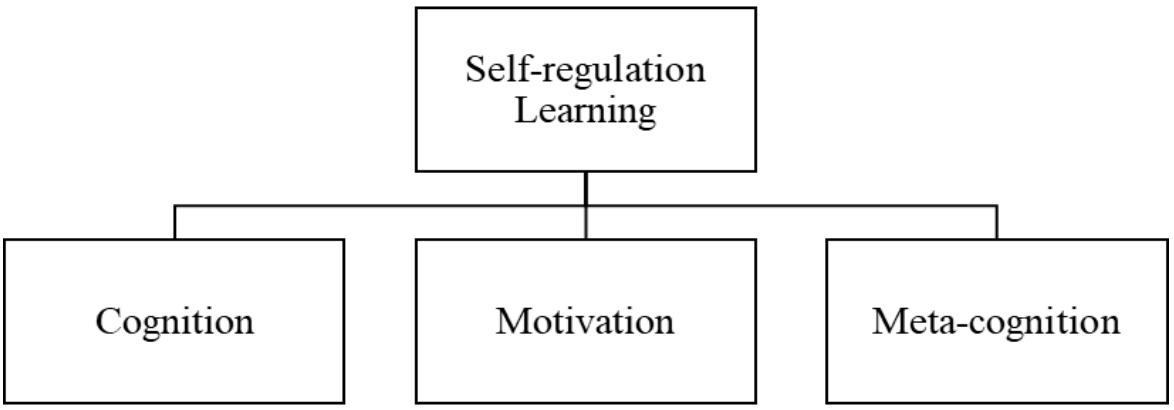

Figure 2.1 Self-regulation components from Research Gate (https://images.app.goo.gl/ghbJLikA83CQioJX6)

Subcomponents of encoding, organization, elaboration, and inference are part of the cognitive component. The capacity to process information that is now in memory that works with the aim to retain it in long-term memory is referred to as encoding. Long-term memory is believed to be everlasting and has an infinite capacity, while working memory is believed to be transient and limited. The arrangement and sorting of information in long-term memory is referred to as organization (Carlo, 2017).

Two components of meta-cognition mostly named as knowledge of cognition and regulation of cognition. Knowledge of cognition states to what we identify about cognition and possess three subparts. The first declarative knowledge comprises of awareness about us as learners and performance is affected by what type of factors. For example, most adult learners identify the limits of their memory system and on the basis of knowledge, plan accordingly. Procedural knowledge, as compared, brings up to information about policies and other processes. For illustration, most adults keep a basic collection of suitable strategies such as note-taking, slowing down for vital information, skimming insignificant information, using cues, briefing key ideas and periodic self-testing (Mahdavi, 2014).

Regulation of cognition typically includes at least three components, such as, Planning, Monitoring, and Evaluation. Planning involves choosing on methodologies, assigning resources, establishing objectives, and bringing forth pertinent information. Because they plan well, professionals appear to be more self-related. Monitoring represents adults self-evaluating their abilities to regulate their learning, with both regional and worldwide monitoring. In some situations, even experienced adult learners might not make good monitors. Evaluation refers to the outcomes and the regulatory framework of education.

The motivation part comprises four important subcomponents, consisting of self-efficacy, attributions, goal orientations and intrinsic motivation (Conley and French, 2014).

Self-efficacy is an individual's confidence in their ability to perform a task or achieve a goal. It is crucial for self-regulated learning, as it influences learners' engagement and persistence in challenging tasks. Research shows that students with higher self-efficacy are more likely to engage in difficult tasks and persist even after initial failures. Higher self-efficacy is also linked to school achievement and self-esteem. Teachers with higher self-efficacy set higher goals, provide more independence and help students achieve higher levels (Soh et al., 2022).

The term "attributions" refers to causal justifications for situations that occur in our life. For instance, two students might perform poorly on an exam. A student's low performance could be attributed to inadequate hard work by one student and bad luck by another. Different interpretations for the same incident are offered by these attributions. According to the concept

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of attribution, it is our understanding of an event rather than the event itself that has an impact on us (Polkinghorne, 1995).

Beliefs about one's own abilities and how they impact learning are called goal orientations. Students choose to choose learning objectives or performance goals depending on how stable they believe intellect to be. While learning goals seek to enhance competency, performance goals seek to demonstrate competence in educational environments. According to studies, kids who set learning objectives are more flexible and content. Students that are learning-oriented attain more by looking for challenges, persevering, employing approaches, attributing effort to accomplishment, and responding positively to setbacks. Students who are performance-oriented frequently develop maladaptive reaction patterns, including avoiding challenges, giving up after failing once, employing unsuitable tactics, feeling helpless, as well as attributing achievement to other forces (Kaplan and Maehr, 2007).

The term "intrinsic motivation" describes actions taken out of a sense of personal fulfillment and joy as opposed to duties or rewards from outside sources. Instead of acting out of personal desire or mastery, extrinsic motivation, on another side, is doing activities to attain outcomes that are valued externally. Research indicates that intrinsic motivation increases satisfaction and the want to complete the activity again, whereas extrinsic drive might cause apathy or dissatisfaction, which decreases an urge to complete the task again (Bhaduri and Kumar, 2011).

According to Sternberg and Lubart (1996), the ability to find genuine solutions to problems is referred to as creativity. This ability involves considering a certain scenario and issue from several angles.

Creativity can be expressed as combining previous thoughts and redefining previous thoughts. Creativity is a basic skill incorporated in all aspects of human beings' life and the evolution of human beings (San, 1985).

According to Torrance (1974), creativity is "being sensitive to problems, inadequacies, shortage of information, nonexistent elements and incompatibility; identifying challenges, looking for solutions, estimation and hypothesizing or modifying hypothesizes in relation with insufficiencies, selecting and trying one of the solutions, retrial and concluding accordingly".

Torrance (1969) defined creativity as the ability for gaps detection, recommends solutions to solve problems, produce novel ideas, re-combine them and perceive a novel relationship between ideas.

Perkins (1988) defined creativity as follows: "(a) Original and appropriate are the both results of a creative task, (b) A creative person a person with creativity is a person who fairly, routinely produces creative results.

Scholars have just lately begun to investigate the creative process from the standpoint of self-regulation. Because creative work is fundamentally ill-defined, it is necessary to identify and clarify the creative challenge or goal (Reiter-Palmon et al., 1998). Unspecified actions can also result in innovative outcomes; techniques are frequently changed when they fail to provide the desired effects. Furthermore, the decision of whether or not a certain work will be deemed creative and beneficial is typically made by others rather than the creator. Even the general public may recognize more or less typical creative behaviors, reviewers, critics, and audiences all play a crucial part in approving or disapproving creative works (Ivcevic and Nusbaum, 2017).

Rather, creativity is linked to a wide range of interests, candor, openness, and curiosity as well as the capacity to abandon work and continuously assess one's own activities (Ivcevic & Nusbaum, 2017). Creative self-beliefs and emotional regulation skills both contribute to the perseverance required to bring creative ideas to life in goods or performances (Beghetto, 2011).

The creative process involves various emotions that impact performance. Self-regulation is

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crucial for creativity, as it involves managing one's and others' feelings. Supporting and sustaining in self-regulation involves formulating, execution, determination, and emotional management (Ivcevic & Brackett, 2015; Ivcevic & Hoffmann, 2019).

RESEARCH METHODOLOGY

The type of research is quantitative research with casual comparative research method. Quantitative approach involves the collection of numerical data in order to explain, predict or control phenomenon of interest.

Quantitative studies design to describe current conditions, referred as descriptive research. The main aim is to investigate the effect of self-regulation on creative thinking skills of physics students at secondary level. The instrument used in the research was close ended questionnaire. One questionnaire was used as a research instrument to collect information about the effect of self-regulation of student in physics of female students of Laboratory School. Questionnaire was taken from research of (Kanfer, 1970a, 1970b), (Brown, 1998), (Miller & Brown, 1991).
The second instrument used in the research was close ended creative thinking test. It was used to determine creative thinking skills of physics students at secondary level. The creative thinking skill test is design by “Torrance” in 1960 called Torrance Test of Creative Thinking (TTCT). It was observed that majority of the students regulated their goals, behaviors, and was confident about themselves while others reached mediocre level and more than half of the participants showed better creative thinking skills in comparison to others.

RESULTS AND DISCUSSIONS

The current study aimed to explore how science students' self-regulation influences their problem-solving skills in physics at the secondary level. Self-regulated learning, as described by Xiao, Yao, & Wang (2019), involves students' self-directed thoughts, feelings, and actions aimed at achieving their own goals. This includes setting goals, monitoring progress (metacognition), managing time, and adjusting to the physical and social environment. In this perspective, learners continuously adjust their goals and plans based on feedback, enhancing their problem-solving abilities, which, as noted by Chi and Glaser (1985), have been historically pivotal in human development.
This research focuses on exploring the role of self-regulation at an advanced spiritual level, which is associated with heightened self-regulatory abilities, in facilitating individuals' self-realization within their professional endeavors. The study identifies three key components of self-regulation: cognitive, metacognitive, and motivational factors. In educational contexts, self-regulation entails students' capacity to monitor and adjust their actions throughout the learning process. Ozhiganova's (2016) four-level model of self-regulation and its connection to professional activities is also considered in this investigation.
At the psycho-physiological level, individuals possess the capability to regulate their emotional and psycho-physiological states. On the socio-psychological level, they exhibit self-regulation within social interactions. At the psychological level, individuals demonstrated the ability to regulate their activities, personal self-control and pursuit of self-improvement, and the capacity to exercise willpower and harness energy. Finally, at the spiritual level, the highest form of self-regulation is characterized by individuals' alignment with higher values and the profound meanings of existence.
Creative thinking is a cognitive ability that entails producing fresh and inventive ideas, solutions, or insights, surpassing conventional or habitual methods. It encourages individuals

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to delve into novel viewpoints, establish links between seemingly disparate concepts, and generate distinctive results.

Institutions significantly influence science students' self-regulation and problem-solving abilities in physics. Our findings suggest that students attending private schools exhibit greater interest and engagement in solving physics problems. Frequency distribution analysis reveals that students with high confidence levels tend to struggle with word problems in physics. Conversely, those who prioritize physics and actively engage in solving numerical problems demonstrate proficiency in physics problem-solving compared to their peers.

The data collected for the study was analyzed and presented in the form of tables along with interpretation. Data analysis was done by using statistical package for social science software (SPSS) version 22.0.

Analyzed results are presented as under:

Table 1: Result of Frequency of Respondent's Gender

Gender	**Frequency**	**%age**
Female	50	100
Total	50	100

The table 1 indicates that the respondents were 100% of female gender.

Table 2: Seven Factors of Self-Regulation

Categories	**No. of items**	**Total**
Receiving relevant information	1, 8	02
Evaluating the information and comparing it to norms	2, 9, 15	03
Triggering change	3, 10, 16	03
Searching for options	4, 11, 17	03
Formulating the plan	5, 12, 18	03
Implementing the plan	6, 13, 19	03
Assessing the plan's effectiveness	7, 14, 20	03
Total		**20**

Table 2 shows seven factors of self-regulation every factor contain items for the determination of the motivation and dedication of the respondent's for the establishment and completion of their goals. Dedication helps respondent to remain loyal and strong for the achievement of their specific goals, even in the face of obstacles, or lack of immediate results.

Table 3: Represent questions related to creative-thinking skills

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Statements	Frequency	%age
12 ribbon yards to use for gifts by Sammy	50	100
24 Cookies to class by Mr. Richter	41	82
Next number in pattern	7	14
Group of letter which does not belong	6	12
Fourth word related to blue/cake/cottage	15	30
Which use brick	33	66

Table 3 presents the questions related to creative-thinking skills. Creative thinking supports problem-solving, innovation, and adaptability, while also strengthening students' confidence and communication abilities. It allows learners to express their emotions, manage their feelings, and gain deeper self-understanding, ultimately contributing to a more personalized learning experience.

The result demonstrated that about 68% of the students regulated their goals, behaviors, and was confident about themselves while 32% was confused in decision-making, and feels their behavior same as their other peers. In case of cognitive-skills test, the findings revealed that about 54% of the participants showed better creative thinking skills in comparison to their classmates. Data retrieved from the questionnaire and test suggests strong relationship between self-regulation and creative thinking skills of physics students at secondary level.

CONCLUSION

Based on our research findings, it was determined that the majority of secondary-level students acknowledge monitoring their progress towards their goals. However, many students perceive their behavior as similar to others. Additionally, a significant portion of students indicated receiving feedback about persisting too long on tasks. While most students express doubts about their capacity for change, they also admit to struggling with decision-making and getting easily distracted from their plans. Despite this, they recognize the importance of self-reward for progress. Moreover, some students lack awareness of the consequences of their actions until it's too late. Although, they find it challenging to see the benefits of changing their ways, they generally believe in their ability to achieve set goals. However, they also concede to having difficulty following through on decisions and managing multiple plans concurrently. Despite these challenges, students demonstrate a willingness to consider alternative approaches and express confidence in their ability to effect change, although feeling overwhelmed by the array of choices. Overall, while students acknowledge certain limitations in their self-regulation and decision-making abilities, they also exhibit a readiness to adapt and improve.

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