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Enacting Creative Thinking Skills Using Design Process in Technology Classrooms

Praygod Bonginkosi Nkosi*

Master's in technology education, Lecturer, Department of Mathematics, Science and Technology Education, University of Limpopo, Polokwane, South Africa, https://orcid.org/0000-0002-7000-7684

Thokozani Isaac Mtshali

PhD in Technology Education, Senior Lecturer, Department of Technology and Vocational Education, Tshwane University of Technology, Pretoria, South Africa, https://orcid.org/0000-0002-9643-5708

***Correspondence email**: *praygod.nkosi@ul.ac.za.*

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Abstract: Creativity is rapidly becoming central to scholarly discourse, research, and education practice. It is central to modern society and forms the basis for innovation and progress. In the current era, creative thinking skills (CTS) are pivotal skills one must possess to compete, succeed, and participate in the global economy. Therefore, the Ministry of Education must ensure the cultivation of such skills in today's classrooms to produce the kind of learners that will be the perfect fit for societal needs around the globe. As such, Creative Thinking Skills development is one of the core objectives of the South African Curriculum and Technology Education (TE), encouraging learners to be creative and innovative. The study examined how Technology teachers enact Creative Thinking Skills in their classrooms. The study was based on a qualitative research approach complemented by the case study research design. Purposive sampling was used to sample four Technology Education teachers as study participants. Data was collected through interviews and complemented by observations and document analysis concerning four Technology teachers. The study discovered that although the design process (DP) is available to support them, teachers still struggle to adequately articulate the idea of creative

thinking and what it entails. The study suggests that to support learners, technology teachers should engage themselves in a lesson study approach with colleagues in nearby districts to receive continuous pedagogical training that will help them understand the nature and components of creative thinking.

Keywords: Creativity, Technology, Teachers, Classroom, Design process.

Introduction

Creative skills are essential for success in the 21st century as societal problems become increasingly interdependent, global and complex. This is echoed by the recent contribution to creative and critical thinking skills in the Technology classroom. For example, Ramaboea et al. (2023) studied creative ways of teaching Mechanical Systems Practical Assessment Task (PAT) through the 9E instructional model. These authors propound that teachers who elaborate on every technological concept presented to learners are cognisant of the role of elaborating for creative purposes. According to Mahlangu and Mtshali (2024), creativity is the most crucial element for young people, as most have poor literacy skills. Creativity as a backbone concept in Technology subjects has not been well understood and adequately framed. Technology teachers are constantly battling with creative ideas to teach and assess self-made technological activities (Patricia et al., 2023). The drastic developments in modern technology have posed a challenge to everyone, particularly teachers who must ensure that technology in their classrooms is adequately integrated with the instruction. There is an agency for teacher education to focus on creativity, which would enable technology classrooms to flourish with creative ideas that are pragmatic to real-life scenarios. In essence, teacher education should focus on technologies in the classroom and teaching approaches that will creatively engage learners with content (Ndwandwe et al., 2024).

Creative skills are broadly viewed as a desired attribute for the quality of thinking that lays a foundation for innovation and change (Brandt, 2023). Furthermore, Tan (2020) argues that in the 21st century, Creative Thinking Skills have become increasingly important in creating a fertile ground for learners' success in modern society. In technology education, human creativity manifests in how learners understand their role in technological creativity (Khubayi et al., 2024). The preceding discussion is that Creative Skills Teaching should focus on teacher-classroom practices because such teaching highlights learners' creative agency (Creely et al., 2021). Creative skills are the ultimate skills to possess by any learner exiting the education system in the 21st century (Dilekçi & Karatay, 2023). Jatmiko et al. (2022) emphasise that today's creative industries and services comprise a rising portion of the global economy, with creativity as its central activity. Chen et al. (2022) allude that encouraging culture for developing Creative Thinking Skills is demonstrated in activities provided to the learners. Moreover, teachers who teach creatively inspire students' creativity by imparting their passion, creativity, curiosity, and other skills (Swargiary, 2024). Creative thinking is not an innate quality of only a few selected individuals. Hence, it can be learned, practised, and developed using proven techniques to enhance and stimulate creative abilities, ideas, and results (Chen et al., 2022; Vogel, 2014).

In South Africa, the Department of Basic Education (2011) developed the Curriculum and Assessment Policy Statement (CAPS), which states that subjects related to technology should give learners the chance to solve problems creatively by combining critical and creative thinking with practical skills that connect abstract ideas to basic understanding. The CAPS also calls for applying various skills, including decision-making, critical and creative thinking, and problem-solving abilities in an authentic context. On the other hand, Technology as a school subject is expected to provide an environment conducive to inculcating positive attitudes, perceptions, and aspirations towards

technology-based careers among learners in this fourth industrial era (Mlambo, 2024). As a subject, technology is intended to stimulate learners to be more innovative and develop Creative Thinking Skills.

Hill-Jackson and Lewis (2023), supporting VanSlyke-Briggs (2019), argue that approaches such as the traditional "drill and kill" or standards-based teaching have often pushed creativity out of the curriculum or areas of policy and assessment. Teachers generally believe that learners are inherently creative, receptive to new experiences, and drawn to novel things. However, the natural quality will vanish if not nurtured correctly (Wilson, 2018). As such, the current education system does not provide risk-taking platforms and the freedom for learners to explore (Jones et al., 2023).

Teachers' challenges are that they do not know how to promote creativity within learners. Moreover, they lack experience and knowledge about the creative process, which makes it difficult for them to teach and encourage creativity in their learners (Ndwandwe et al., 2024). Creativity is rapidly becoming central to scholarly discourse, research, and education practice. Therefore, since they are becoming essential to how creativity is approached throughout the educational lifespan, creativity is being understood, nurtured, and linked with industry. It is also being understood how educational institutions interpret and prepare students for futures shaped by creative and innovative challenges (Kettler et al., 2021).

Abegglen et al. (2020) argue that developing learners' creativity in education is essential for personal, economic, and social reasons. In recent years, research has revealed that the most potent, innovative people in various fields are highly creative, even in areas outside their professional spectrum, by actively drawing on outside interests and creative ways of thinking to improve their professional practices (Cheng, 2019). Furthermore, Lucchiari et al. (2019) argue that it may be difficult to find creativity in older children and adults because their potential has been muffled by society, which encourages intellectual conformity. Even though this has been the case, Ariba (2019) indicates that there has been little research regarding creativity in classrooms.

Research Problem

Looking at the discussions above, it is safe to state that literature has gone some length to explain the phenomena of creative thinking skills. The most popular theory that foregrounds creativity is championed by Guilford (1973), who posits it to be an ensemble of ideas, objects, skills, imagination and personality traits of perceiving and interacting with the world. From then until now, creative thinking has been perceived the same way. Some authors like Avcı and Durak (2023) have hinged the recent technological developments to the influence of creative thinking and called for education spaces to emphasise its importance in this century. However, not much has been understood about how Technology teachers enact it in their classrooms. The most glaring gap is that literature on teachers' competency to embrace and apply it in different teaching contexts has not been forthcoming. Thus, this study sought to explore how Technology teachers enact creative thinking skills using the design process in Technology classrooms. Thus, this study is guided by the following question.

- How do Technology teachers enact creative thinking skills using the design process in Technology classrooms?

Before exploring such a question, it is important to find out if there are any hypothetical DNAs of creative thinking in literature and how it has been consolidated. See the next segment.

Creative Thinking

Etymologically, the word creative originates from the Latin word "creare", meaning to create, make or produce—the ability to create an object with observable results. Götz (1981) avers that using

etymology as a guide, essentially creativity can be observed as a process of making and successively be distinguished from (a) thinking in its various forms, (b) products' cause and effects, and (c) originality as any quality from its substratum. Creative thinking is not all about using imagination to crack out many innovative ideas but more of a lifestyle, personality trait, way of perceiving the world, interacting with other people, and a way of living and growing (Henriksen & Mishra, 2015). Creativity is a process and a product that produces valuable solutions to problems or novel and practical ideas (Henriksen & Mishra, 2015). Creative thinking is the development of ideas and objects that are new, novel, interesting, effective, and have a specific aesthetic sensibility as a system (Mishra et al., 2013).

According to Murillo-Zamorano et al. (2019), creativity is a greatly desired quality of thinking, often a vital aspect of innovation and change. Creative thinking is increasingly critical for goal attainment in our complex, interconnected world (Strom & Martin, 2017). The originality and uniqueness of ideas characterise creative thinking. However, the originality of ideas does not entirely represent creative thinking; they are only a part of the cognitive and complex phenomenon of creative thinking (Runco & Acar, 2012). Creativity is a learning habit that calls for skills and an understanding of the context in which it is exploited. (Higuera Martínez et al., 2021).

Guilford (1973) outlines fifteen (15) characteristics of creativity (Table 1). Flexibility turns ideas and materials into new, different, and unusual uses. Fluency refers to the ability to think of many ideas and solutions. Elaboration means working out the details of an idea or solution. Tolerance of ambiguity means the ability to bring about reconciliation without tension. Originality signifies the ability to go beyond commonly accepted ideas. The breadth of interest signifies the broad meaning. Sensitivity refers to the ability to see deficiencies and needs in life. Curiosity refers to active experimentation with new ideas. Independence means thinking things through one's self-reliance and forcefulness. Reflection signifies the ability to evaluate ideas as well as new ideas. Action refers to the ability to put ideas into action. Concentration and persistence mean the ability to work hard. Commitment means it signifies deep involvement. Expression of total personality refers to expressing both male and female sides of nature. A sense of humour means the ability to express humour in the face of contradictions and ambiguities in life.

Table 1

Characteristics of Creativity

Character	Description
Flexibility	The ability to go beyond tradition, habits, and the obvious. To turn ideas and materials into new, different, and unusual uses.
Fluency	The ability to think of many ideas and possible solutions to a problem.
Elaboration	The ability to work out the details of an idea or solution.
Tolerance of ambiguity	The ability to hold conflicting ideas and values and to reconcile without undue tension.
Originality	Divergent rather than convergent thinking, going beyond commonly accepted ideas to unusual forms, ideas, approaches, and solutions.
Breadth of interest	Wide range of interests with much more concern for the "big ideas," broad meanings, and implications rather than for small details and facts for the sake of facts.
Sensitivity	The ability to sense problems, to see deficiencies and needs in life, and the challenge to find solutions and fill these needs.
Curiosity	Openness to new ideas and experiences, the capacity to be puzzled, actively experimenting with ideas, and the pleasure of seeking and discovering ideas.
Independence	I am thinking things through my self-reliance and forcefulness.

Reflection	The ability to consider and reconsider, evaluate our ideas and the ideas of others, take time to achieve understanding and insight, look ahead and plan, and visualise the complete picture.
Action	The ability to put ideas into action, to begin, help, and shape, with high energy and enthusiasm, these ideas.
Concentration and persistence	The ability to work long, consistently and persistently with extraordinary concentration.
Commitment	Deep involvement, intense commitment, deep caring, almost metaphysical.
Expression of total personality	Expression of both male and female sides of nature sometimes leads to tension in our society.
Sense of humour	The ability to see and express the humour in the contradictions and ambiguities of life.

Source: Guilford (1973).

The following section presents the design process considered the backbone of teaching technology in South Africa.

Design Process

According to Kim et al. (2023), the nature and philosophy of Technology Education (TE) suggest that innovative products are designed and constructed to find new solutions to problems through the implementation of a technological process known as the "Design Process" (DP). Furthermore, In TE, the Design Process provides the learner with ways to solve problems through which understandings are developed (Warr et al., 2020). Moreover, it is a process that involves devising something through an interactive and open-ended process of producing and developing components, systems, and processes. Moreover, it is an experiential component characterised by problem-solving (Boud et al., 2018). Through the Design Process, knowledge, skills, and resources are used to meet human needs and wants by designing, making, and evaluating products (McLain et al., 2019). The Design Process provides a step-by-step approach to constructing an artefact while considering the scientific information and application of technical skills (Juškevičienė et al., 2021). The DP is the ongoing endless procedure used to develop a product creatively (Cheng, 2019).

Table 2 presents the Design Process applicable to South African schools (Department of Basic Education, 2011). The table illustrates the nature of the Design Process, which comprises Investigating, Designing, Making, Evaluating and Communicating (IDMEC). Investigation refers to conducting the relevant information. Design (as part of the process) refers to generating possible solutions to a specific problem. Make means the application of tools and adhering to safety. Evaluation involves the ability to evaluate the solutions, decisions, and results. Communication refers to various methods used to make a presentation.

Table 2

Design Process

The Process	Activities
Investigation	Seek information, conduct a relevant investigation, grasp concepts, and gain insight, determine new techniques.
Design	Brief design, generate possible solutions, draw graphics (2.3D) ideas, choose the best solution, and justify.
Make	Use tools and equipment, building, testing, and modifying products, as well as a safe and healthy atmosphere.

Evaluate	Evaluate actions, decisions, and results; evaluate solutions and the process followed; suggest necessary improvements; evaluate constraints.
Communicate	Presentation, a record of the process

Source: Department of Basic Education (2011).

Methods

A qualitative approach was used to obtain a more comprehensive understanding of teachers' planning process regarding fostering creative thinking skills in their teaching. The qualitative approach was selected as it aided in the development of a depth of meaning where the participants and their understandings formed the focal point of the research, explaining qualitative research as an approach that aims for depth rather than understanding (Merriam & Grenier, 2019; Tracy, 2019). A descriptive case study by Kin (2021) was used to examine the contextual conditions and portray how Technology teachers support learners in developing Creative Thinking Skills.

Sampling

Purposive sampling provided a detailed, contextualised description of the study being investigated (Neuman, 2013). Four Technology teachers with vast knowledge and experience in teaching technology were purposively selected. Two of the four Technology teachers have obtained a Diploma in Teaching, and the others have a bachelor's degree in Technology Education. Their teaching experience ranges from five to sixteen years.

Data Collection

Data was collected from four participants through semi-structured and complemented by classroom observations and document analysis to make sense of participants' responses and context. The interview collects data through semi-structured oral questioning (Roulston & Choi, 2018). Observation is a systematic process of taking notes and recording occurrences and the behaviour of participants without asking questions or communicating with them (Renz et al., 2018). An observation schedule (Figure 1) documents the classroom interaction. Document analysis is part of the larger domain of documentary research methods (Wagner et al., 2012). In this study, document analysis refers to the lesson plans. The characteristics of creativity described by Guilford (1973) (Table 1) were used to develop interview questions and observation schedules. This exercise affirms the credibility of the study. The participants were interviewed separately, and the observations were conducted during class sessions to corroborate what was highlighted during the interviews. Corroboration provided a broader understanding of the subject at hand. The researcher used these three data collection procedures to provide enough information from different angles to make clearly defined conclusions (Merriam & Grenier, 2019). Permission was sought to conduct the study through the Department of Basic Education in Ehlanzeni District in Mpumalanga Province.

Interviews. The interview questions were derived from Guilford (1973), as outlined in Table 1. Eight (8) questions were formulated so participants responded to each creative thinking character. The focus of the question was to determine the teachers' understanding of the concept of creative thinking. All interviews were conducted face to face, and the interview sessions with each interviewee ranged from 20 minutes to 30 minutes. The semi-structured interview method was used to calm the participants' emotions, as they were not attacked with questions early during the interview. The respondents could divulge appropriate information without fear and could elaborate further on the fundamental meaning of their answers in detail (Dawson, 2019). The interview questions posed were:

(1) What is your understanding of creative thinking?

(2) What are the key features considered to ensure effective teaching and learning of creative thinking skills?

(3) How does the environmental effect influence the learners' level of creativity?

(4) How do you encourage learners to develop curiosity and the desire to explore the critical aspects of creative thinking?

(5) Which approach do you employ to support learners to develop fluency?

(6) How do you promote originality when encouraging learners to develop new ideas?

(7) How do learners consolidate new ideas?

(8) How do you motivate learners to develop creative thinking skills?

Whilst reporting, only relevant questions were selected to understand what this study sought to achieve fully.

Observations. An observation schedule that combines the characteristics described by Guilford (1973) (Table 1) and the design process (Table 2) was developed to guide the observations. Observational methods have the advantage of directly evaluating learners' involvement and engagement in the learning environment. The observations provided the researcher with a platform to explore how the learners learn, interpret, and make sense of the subject and what they do when they lack understanding of the material. Teachers were expected to bring along a lesson plan to class with them. This should cover not less than 60 minutes. Per policy (CAPS), the lesson plan should clearly outline everything to be done in class. It should be noted that the lesson plan is expected to always have 30 minutes of the 60 minutes for practical work covering the technological process or some parts of it, as it is the cornerstone for teaching and learning Technology. The Design Process provides the platform for the development of Creative Thinking Skills.

Document Analysis. As indicated earlier, document analysis in this study refers to lesson plans. Lesson planning refers to pre-active decision-making that takes place before instructions. It is a process whereby teachers, consciously and unconsciously, make decisions that affect their behaviour and that of learners. Cognisant decision-making, such as lesson planning, involves teachers' conscious efforts in developing a coherent system of activities that promote the development of learners' cognitive structures (Orgoványi-Gajdos, 2016).

Data Analysis

Thematic and content analysis methods were employed to analyse the data. Thematic data analysis methods were used to analyse interview questions, while content data analysis was used for observation and document analysis. The content analysis entails an inductive and interactive process to identify similarities and variances in the text that substantiate or disprove a proposed theory (Ridder et al., 2014). Data were broken up and separated into meaningful units, summarised and subsequently narrated.

Results

As a reminder, this study is concerned with understanding how technology teachers enact critical thinking skills using the design process in technology. The participants who were given pseudonyms, namely Jill, Paul, Joy, and Blade, were interviewed. The researcher wanted to first determine if they understood the concept of creative thinking, and this is how each responded.

Jill

Jill described creative thinking as 'allowing learners to express themselves in different ways through a mini-PAT'.

Paul

Paul described creative thinking as "the set of skills that allow a learner to design to solve a societal problem through innovation".

Joy

Joy explained the creative thinking concept as "coming with something new and unique in solving a problem".

Blade

According to Blade, creative thinking gives individuals a chance to think outside the box, and learners are given projects to solve problems in an innovative way.

After responding to the above, the researcher asked them to outline how they use the design process to enact creative thinking, and this is what each said.

Jill

Jill stated that he usually uses grouping in class to allow her to attend to all learners in their respective groups. Jill mentioned that he conducts proper demonstrations through hands-on modelling or videos while teaching and avoids theorising about content. He also stated that he applauds if one has done impressively, shared encouraging words, have positive talks with other learners who contribute effectively to the PAT lessons.

Paul

Paul mentioned that he starts by giving learners a contextualised problem that can be solved in various ways. He then asks learners to indicate how they will solve the problem, and those with similar ideals are grouped together so they can use the technological design process to become more creative. He also mentioned that this strategy increases creative design competition among learners, as each group wants to outperform the others.

Joy

Joy mentioned that he always groups learners in class and teaches them in context so they can relate, allow them to share information and embrace diversity. She further stated that she instils belief in learners and makes them believe in what they do at all times, as long as they can justify their decisions. This helps them creatively navigate the design process, knowing someone believes in them. Such motivation always brings out the best in learners' psychomotor skills.

Blade

Blade mentioned that all his activities that follow the design process should be viscerally, tactilely or felt by learners. In this way, a learner is able to quickly connect to what he wants to creatively make. So, he stated that he gives the learners new topics more often to research on and do presentations in class either as groups or as individuals.

Discussion

The responses above make it clear that teachers understood the idea of creative learning to some extent. The most impressive part was that *Jill* could align his understanding with a practical assessment task. Msimango and Mtshali (2024) state that a practical assessment task, popularly known as PAT, is a compulsory activity for all learners of Technology that aims to assist learners in actualising their creative and critical psychomotor skills. Looking at Guilford's (1973) version of creative thinking, where he defines it as originality or novelty and appropriateness or adaptiveness (i.e., relevance) to the problem to be solved, it is safe to assume that every activity that learners and teachers do in Technology classroom should foster creativeness.

Different forms of creativity can be developed during the development of creativity, ranging from minor replications to major redirections in thinking (Nkosi et al., 2023). *Jill* stated that he normally uses grouping in class to attend to all learners with similar ideas. His response resonates with Magolego et al. (2022), who state that creativity does not occur in isolation but in society, where there is always the influence of cultural, economic, and political times affecting a person's creativity.

A creative process's primary goal is to push thinking past preconceived notions, ignite curiosity, reject structured procedures and rational, conventional ideas, rely on the imaginative, divergent, and random, and weigh multiple options and solutions (Dodd, 2023). When one looks at Paul's assertion that he groups all learners with similar creative responses, one sees his way of enacting creative thinking is necessary. Again, *Blade* mentioned that he gives the learners new topics more often to research and do presentations in class, either as groups or as individuals. According to Blose and Gumbo (2024), motivation is highlighted as essential to creative achievement. It has great potential to promote a person pursuing unachieved goals during the creative process. Hence, what *Joy* does in her class is motivate learners who are showing accelerated efforts on their creativity to get motivational remarks from the teacher.

Teachers' approaches to practice are influenced by their beliefs about the subject matter, learning, teaching, and technology (Bowman et al., 2022). Ndwandwe et al. (2024) argue that creative thinking depends on other attributes, such as environment and technologies; it also requires reflection, encourages engagement, and develops confidence and responsibility. The researcher noted that although all participants were not structurally immersed in enacting creative thinking skills, creative traits could be found in most of their actions. As a result, this study noted that teachers do not adequately enact creative skills in their classroom practices; it comes briefly and unconsciously from teachers. It is worrisome that teachers are not competent enough to follow all transcripts of enacting creative thinking in their classrooms. Considering how comprehensive Guilford's (1973) model on creative thinking is, it emerges that the participants demonstrated a capacity for flexibility, elaboration, originality, curiosity, and independence. The authors considered all the characteristics of creative thinking as an ongoing learning process.

Conclusion

Given the study findings, teachers demonstrated linear and unstructured understanding of the concept of creative thinking and what it entails, lack of policy adherence, and failure to keep up with current trends that constantly influence the cause of teaching and learning, particularly in the Technology classroom. Technology teachers need to fundamentally understand creative thinking as a concept concerning Creative Thinking Skills development. Teachers are expected to provide the necessary support to learners to follow the design process during any problem-solving, and all the design process steps are pivotal for developing creative thinking skills. The participants somewhat demonstrated an understanding of creative thinking. Technology, as a subject in South Africa, stimulates

learners to be innovative and develop their creative and critical thinking skills. Therefore, it is imperative that technology teachers fully comprehend the nature and aspects of creative thinking in order to support learners. Further study on exploring creative thinking skills, mainly focusing on learners, is recommended to determine how much technology teachers could support learners in developing Creative Thinking Skills.

Suggestions for Future Research

The above findings indicate that Technology teachers use design processes to teach practical assessment tasks. They know most features of the design process and how to teach it to learners. The shortcomings are that Technology teachers do not have technologically sound reasons for their actions. In the case of enacting creative thinking skills, they do not understand how to enact creative skills step by step and align them with content and context. Even if they motivate learners to improve their creative activities, this turns out to be an unconscious pedagogical event and not any specific reasons that could be associated with the technological design process.

Unequivocally, there is a great need for studies that will closely examine teachers' reasons behind their actions in technology classrooms, planning knowledge, and appraisal strategies for learners who demonstrate competency in hands-on activities. It has not been easy to generalise the findings of studies conducted in technology, so the sample size should be considered in the future.

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Conflict of Interest

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References

Abegglen, S., Burns, T., Maier, S., & Sinfield, S. (2020). Global university, local issues: Taking a creative and humane approach to learning and teaching. In E. Sengupta, P. Blessinger, & M. Makhanya (Eds.), *Improving Classroom Engagement and International Development Programs: International Perspectives on Humanizing Higher Education* (vol. 27, pp. 75–91). Bingley: Emerald Publishing Limited. https://doi.org/10.1108/S2055-364120200000027007

Ariba, O. T. (2019). *Enhancing children's early years mathematical creativity through the visual arts* [Unpublished doctoral dissertation]. Johannesburg: University of Johannesburg. https://hdl.handle.net/10210/411988

Avcı, Ü., & Durak, H. Y. (2023). Innovative thinking skills and creative thinking dispositions in learning environments: Antecedents and consequences. *Thinking Skills and Creativity*, *47*, Article 101225. https://doi.org/10.1016/j.tsc.2022.101225

Blose, P., & Gumbo, M. T. (2024). Developing a framework for integrating IKS in technology education with sustainable development principles. *African Journal of Research in Mathematics, Science and Technology Education*. https://doi.org/10.1080/18117295.2024.2356416

Boud, D., Ajjawi, R., Dawson, P., & Tai, J. (Eds.). (2018). *Developing evaluative judgement in higher education: Assessment for knowing and producing quality work*. London: Routledge. https://doi.org/10.4324/9781315109251

Bowman, M. A., Vongkulluksn, V. W., Jiang, Z., & Xie, K. (2022). Teachers' exposure to professional development and the quality of their instructional technology use: The mediating role of teachers' value and ability beliefs. *Journal of Research on Technology in Education*, *54*(2), 188–204. https://doi.org/10.1080/15391523.2020.1830895

Brandt, W. C. (2023). *Measuring student success skills: A review of the literature on creative thinking*. Center for Assessment. https://www.nciea.org/wp-content/uploads/2022/04/CFA-CreativityLitReport-Final.pdf

Chen, S. Y., Lai, C. F., Lai, Y. H., & Su, Y. S. (2022). Effect of project-based learning on development of students' creative thinking. *The International Journal of Electrical Engineering & Education*, *59*(3), 232–250. https://doi.org/10.1177/0020720919846808

Cheng, V. M. (2019). Developing individual creativity for environmental sustainability: Using an everyday theme in higher education. *Thinking Skills and Creativity*, *33*, Article 100567. https://doi.org/10.1016/j.tsc.2019.05.001

Creely, E., Henriksen, D., Crawford, R., & Henderson, M. (2021). Exploring creative risk-taking and productive failure in classroom practice. A case study of the perceived self-efficacy and agency of teachers at one school. *Thinking Skills and Creativity*, *42*, Article 100951. https://doi.org/10.1016/j.tsc.2021.100951

Dawson, C. (2019). *Introduction to research methods 5th edition: A practical guide for anyone undertaking a research project*. London: Robinson.

Department of Basic Education. (2011). *Curriculum and Assessment Policy Statement (CAPS) of technology grades 7–9*. Pretoria: Department of Education. https://www.education.gov.za/Portals/0/CD/National%20Curriculum%20Statements%20and%20Vocational/CAPS%20SP%20%20TECHNOLOGY%20GR%207-9.pdf?ver=2015-01-27-160218-077

Dilekçi, A., & Karatay, H. (2023). The effects of the 21st century skills curriculum on the development of students' creative thinking skills. *Thinking Skills and Creativity*, *47*, Article 101229. https://doi.org/10.1016/j.tsc.2022.101229

Dodd, N. E. (2023). *The process of spark in creativity, innovation, crisis and chaos, and calling* (Unpublished doctoral dissertation]. Pepperdine University. https://doi.org/10.1016/j.tsc.2022.101229

Götz, I. L. (1981). On defining creativity. *The Journal of Aesthetics and Art Criticism*, 19(3), 297–301. https://philpapers.org/rec/GTZODC

Guilford, J. P. (1973). *Characteristics of creativity*. Springfield: Department of Exceptional Children, Gifted Children Section. https://eric.ed.gov/?id=ED080171

Henriksen, D., & Mishra, P. (2015). We teach who we are: Creativity in the lives and practices of Accomplished. *Teachers College Record, 117*(7), 1–46. https://doi.org/10.1177/016146811511700708

Higuera Martínez, O. I., Fernández-Samacá, L., & Serrano Cárdenas, L. F. (2021). Trends and opportunities by fostering creativity in science and engineering: A systematic review. *European Journal of Engineering Education*, *46*(6), 1117–1140. https://doi.org/10.1080/03043797.2021.1974350

Hill-Jackson, V., & Lewis, C. W. (Eds.). (2023). *Transforming teacher education: What went wrong with teacher training, and how we can fix it*. New York: Routledge. https://doi.org/10.4324/9781003448365

Jatmiko, B., Handayani, S. D., Udin, U., Suryandani, E., Kusumawati, R., Laras, T., & Raharti, R. (2022). Key-factor strategy of creative industry in distribution channel: A SWOT analysis method. *International Journal of Sustainable Development & Planning*, *17*(6), 1895–1904. https://doi.org/10.18280/ijsdp.170624

Jones, L., Rogers, R., Rogers, D., McClinton, A., & Painter, L. (2023). Risk takers: PDS partners developing and sustaining antifragile teachers. *School-University Partnerships*, *16*(2), 144–153. https://doi.org/10.1108/SUP-04-2023-0018

Juškevičienė, A., Dagienė, V., & Dolgopolovas, V. (2021). Integrated activities in STEM environment: Methodology and implementation practice. *Computer Applications in Engineering Education*, *29*(1), 209–228. https://doi.org/10.1002/cae.22324

Kettler, T., Lamb, K. N., & Mullet, D. R. (2021). *Developing creativity in the classroom: Learning and innovation for 21st-century schools*. New York: Routledge. https://doi.org/10.4324/9781003234104

Khubayi, F. L., Ncisana, L., & Mtshali, T.I. (2024). Investigating the effectiveness of using YouTube videos as an alternative learning media for Grade 11 life sciences learners. *E-Journal of Humanities, Arts and Social Sciences*, 5(6), 1001–1014. https://doi.org/10.38159/ehass.20245616

Kim, B., Joines, S., & Feng, J. (2023). Technology-driven design process: Teaching and mentoring technology-driven design process in industrial design education. *International Journal of Technology and Design Education*, *33*(2), 521–555. https://link.springer.com/article/10.1007/s10798-022-09739-0

Kin, R. K. (2012). *Application of case study research* (3rd ed.). Los Angeles: SAGE Publications, Inc.

Lucchiari, C., Sala, P. M., & Vanutelli, M. E. (2019). The effects of a cognitive pathway to promote class creative thinking. An experimental study on Italian primary school students. *Thinking Skills and Creativity*, *31*, 156–166. https://doi.org/10.1016/j.tsc.2018.12.002

Magolego, M. P., Mtshali, T.I & Ramaligela, S.M. (2022). Nurturing creativity as the 21st century skill: Effective strategies for promoting creativity in the Technology classroom. *NeuroQuantology, 20*(19), 2921–2931. https://neuroquantology.com/media/article_pdfs/2921-2931.pdf

Mahlangu, S. M., & Mtshali, T. I. (2024). Factors contributing to poor literacy among Grade 4 learners in Gauteng Province of South Africa. *Zhongguo Kuangye Daxue Xuebao*, *29*(2), 77–82. https://zkdx.ch/journal/zkdx/article/view/35

McLain, M., Irving-Bell, D., Wooff, D., & Morrison-Love, D. (2019). How technology makes us human: Cultural historical roots for design and technology education. *The Curriculum Journal*, *30*(4), 464–483. https://doi.org/10.1080/09585176.2019.1649163

Merriam, S. B., & Grenier, R. S. (Eds.). (2019). *Qualitative research in practice: Examples for discussion and analysis* (2nd ed.). San Francisco: Jossey-Bass.

Mishra, P., Yadav, A., & Deep-Play Research Group. (2013). Rethinking technology & creativity in the 21st century. *TechTrends, 57*(3), 10–14. https://www.academia.edu/download/32019522/2013_Mishra_Yadav_TechTrends-1.pdf

Mlambo, P. B. (2024). Investigating ChatGPT: A threat or benefit to higher education?. *Futurity Education, 4*(1), 274–289. https://doi.org/10.57125/FED.2024.03.25.14

Msimango, S. M., & Mtshali, T. I. (2024). How civil technology teachers teach woodworking practical skills in schools: A case of Ekurhuleni East, South Africa. *E-Journal of Humanities, Arts and Social Sciences (EHASS)*, *5*(8), 1443–1453. https://doi.org/10.38159/ehass.2024581

Murillo-Zamorano, L. R., Sánchez, J. Á. L., & Godoy-Caballero, A. L. (2019). How the flipped classroom affects knowledge, skills, and engagement in higher education: Effects on students' satisfaction. *Computers & Education*, *141*, Article 103608. https://doi.org/10.1016/j.compedu.2019.103608

Ndwandwe, K. P., Ramaligela, M. S., & Mtshali, T. I. (2024). Smartboard enhanced creativity in the technology classroom: Lessons on mechanical systems and control. *Jurnal PendidikanTeknologi dan Kejuruan*, *30*(1), 145–156. https://doi.org/10.21831/jptk.v30i1.72289

Neuman, D. (2014). Qualitative research in educational communications and technology: A brief introduction to principles and procedures. *Journal of Computing in Higher Education, 26*, 69–86. https://doi.org/10.1007/s12528-014-9078-x

Nkosi, P. B., Kola, M. I., & Mtshali, T. I. (2023). The paradox of creative thinking skills in the vocational technology classroom: Where do technology teachers go wrong?. *Journal of Positive Psychology and Wellbeing*, *7*(4), 486–497. https://mail.journalppw.com/index.php/jppw/article/view/18072

Orgoványi-Gajdos, J. (2016). *Teachers' professional development on problem solving: Theory and practice for teachers and teacher educators*. Rotterdam: SensePublishers. https://doi.org/10.1007/978-94-6300-711-5

Patricia, M. M., Isaac, M. T., & Manto, R. S. (2023). Enhanced creativity with Mini-PAT: A case of grade 9 Technology teachers in Sekhukhune East. *African Perspectives of Research in Teaching and Learning*, *7*(1), 110–121.

Ramaboea, H. K., Ramaligela, M. S., & Mtshali, T. I. (2023). Teaching mechanical systems practical assessment task through 9E instructional model in a technology senior phase classroom. *African Perspectives of Research in Teaching and Learning*, *7*(3), 537–547. https://www.ul.ac.za/aportal/application/downloads/Article_8_7_2023.pdf

Renz, S. M., Carrington, J. M., & Badger, T. A. (2018). Two strategies for qualitative content analysis: An intramethod approach to triangulation. *Qualitative Health Research*, *28*(5), 824–831. https://doi.org/10.1177/1049732317753586

Ridder, H. G., Hoon, C., & McCandless Baluch, A. (2014). Entering a dialogue: Positioning case study findings towards theory. *British Journal of Management*, *25*(2), 373–387. https://doi.org/10.1111/1467-8551.12000

Roulston, K., & Choi, M. (2018). Qualitative interviews. In U. Flick (Ed.), *The SAGE Handbook of Qualitative Data Collection* (pp. 233–249). London: SAGE Publications Ltd. https://www.torrossa.com/en/resources/an/5018779#page=262

Runco, M. A., & Pritzker, S. R. (Eds.). (2020). *Encyclopaedia of creativity* (3rd ed.). Boston: Academic Press.

Strom, K. J., & Martin, A. D. (2017). *Becoming-teacher: A rhizomatic look at first-year teaching*. Sense Publishers.

Swargiary, K. (2024). *Teaching: A thankless endeavor*. Scholars' Press.

Tan, L. (2020). Design system of stationery and creative products based on information technology. *Journal of Physics: Conference Series, 1574*(1), Article 012122. https://doi.org/10.1088/1742-6596/1574/1/012122

Tracy, S. J. (2019). *Qualitative research methods: Collecting evidence, crafting analysis, communicating impact* (2nd ed.). Wiley-Blackwell.

VanSlyke-Briggs, K. (2019). The demise of creativity in tomorrow's teachers. *Journal of Inquiry and Action in Education*, *10*(2), 90–111. https://digitalcommons.buffalostate.edu/jiae/vol10/iss2/5

Vogel, T. (2014). *Breakthrough thinking: A guide to creative thinking and idea generation*. Newton Abbot: F & W Media International, Ltd.

Wagner, C., Kawulich, B., & Garner, M. (2012). *Collecting data through observation, doing social research: A global context*. London: McGraw-Hill Higher Education.

Warr, M., Mishra, P., & Scragg, B. (2020). Designing theory. *Educational Technology Research and Development*, *68*, 601–632. https://doi.org/10.1007/s11423-020-09746-9

Wilson, R. (2018). *Nature and young children: Encouraging creative play and learning in natural environments* (3rd ed.). London: Routledge.