Fostering Creativity through Design and Technology Education

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ABSTRACT

The challenges faced by contemporary societies, together with the on-going change characterizing these societies, reveal the need for citizens who are able to think differently and adapt what is already known to new, unknown situations (Cropley, A., 2011). This ensures that change is pro-actively managed. Education plays an important role in supporting active citizenship (Apple, 2013), where a methodology that promotes creativity ensures the effectiveness of pluralism in democratic societies. Teachers, however, are faced with dilemmas, having to compromise between the requirements for creativity and the demands of education systems (Atkinson, 2000; Runco, 2014a). Design and Technology Education has a potential role in addressing these dilemmas, due to the authenticity afforded and the potential of design practice to foster the metacognition required for creativity (Christiaans & Venselaar, 2005). This paper presents the research conducted to build a toolkit for secondary school Design and Technology Educators, intended to capitalize on this potential. It was developed following an exploration process aimed at identifying a pedagogy that facilitates the fostering of creative mindsets through the subject. This process consisted of interviews with Design and Technology teachers to understand creativity in the local classroom, in addition to a literature review. The toolkit was then evaluated through interviews with other Design and Technology teachers. The underlying philosophy of the toolkit is based on the 4P framework (Rhodes, 1961) – Person, Process, Product, and Press – to address creativity holistically, with the creative Person as its long-term goal. This is embodied through the design process at the core of the toolkit, facilitated using the spiral curriculum (Bruner, 1977) and specific design tools. The evaluation of the toolkit shows that it can support high-level thinking required for creativity, confirming the role of Design and Technology Education in preparing present and future generations for the society they design and live in.

Key Words: Creativity, Design and Technology, Toolkit, Teaching resources.

1. INTRODUCTION

In the face of long-term challenges, and on-going change such as the realities of climate change and industry 4.0, contemporary societies require citizens who are able to think differently and adapt what is already known to new, unknown situations (Cropley, A., 2011; Cropley, A., 2020). Education plays a role in supporting active citizenship (Apple, 2013) through a "problem-posing" methodology based on creativity (Freire, 1993).

Teachers, however, have to compromise between the requirements for creativity and the demands of education systems (Atkinson, 2000; Runco, 2014a). Design and Technology (D&T) Education can potentially address these dilemmas, due to the authenticity afforded and the potential of design practice to foster the metacognition required for creativity (Christiaans & Venselaar, 2005). Keirl (2008), points out how besides material objects humans also 'design' society, culture, and political systems amongst others.

This paper mainly describes the research conducted to inform and develop a Toolkit (unpublished) for secondary school D&T teachers to help them foster creativity amongst students aged eleven to sixteen. The guiding research question is the following:

How can D&T teachers make lessons more conducive to creativity?

2. LITERATURE REVIEW

2.1. Defining Creativity

While there is no straight forward definition for 'creativity' (Fisher, 2004, p.7; NACCCE, 1999), Rhodes' (1961) framework categorising creativity under four inter-related themes helps clarify the scope covered in this study. These themes are: Product, Process, Press, and Person, (Figure 1) referred to as the 4Ps of creativity (Rhodes, 1961). In this study it is being used to define the facets of creativity that will be explored.

Figure 1.
The relationship amongst the 4Ps (Adapted from Hyun-Kyung & Soojin, 2015, Figure 1)
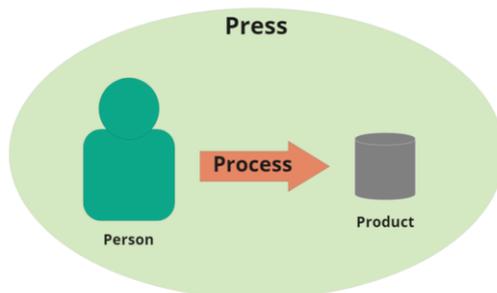
2.2. Creativity in Education

The role of schooling in creativity has not always been interpreted as positive. The need to conform suppresses children's natural creativity (Kelley & Kelley, 2013; Robinson, 2006). When trying to teach for creativity, teachers are often faced with a dilemma from pressures to plan and be accountable (Runco, 2014b).

One question that needs to be asked is whether creativity can be taught. Some believe that creativity emerges spontaneously if not blocked (Cropley, A., 2011; Runco, 2014b). Others believe it can be enhanced through training and explicit instructions (Cropley, A., 2011; Tran et al., 2020). It can then be concluded that the role of education is twofold: the removal of barriers to creativity followed by explicit teaching.

2.3. Creativity in Design and Technology

Design-based learning is a tool that brings real-life problem-solving methods into the classroom. The ill-defined nature of design problems (Cross, 2006; Kimbell & Perry, 2001), allows room for multiple solutions and hence for creativity (Bozkurt Altan & Tan, 2021; Cropley, D. & Cropley, 2010; Lewis, 2005). Furthermore, Howard et al. (2008) highlight the links between creativity and design and how the 4Ps of creativity appear in design.

2.3.1. Process

Process is concerned with the thinking processes to achieve a creative outcome, and hence can include definitions of creativity as 'Problem Finding' and 'Problem Solving' (Cropley, D. & Cropley, 2010; Lille & Romero, 2017; Runco, 2014b).

Comparative studies by Howard et al. (2008) and Warr & O'Neill (2005), later revised by Hyun-Kyung & Soojin (2015), synthesize multiple creative process models under three common stages which can be presented as a divergent-thinking phase followed by a convergent-thinking phase (Figure 2).

Figure 2.
The Creative Process

ANALYSIS ➡ GENERATION ➡ EVALUATION
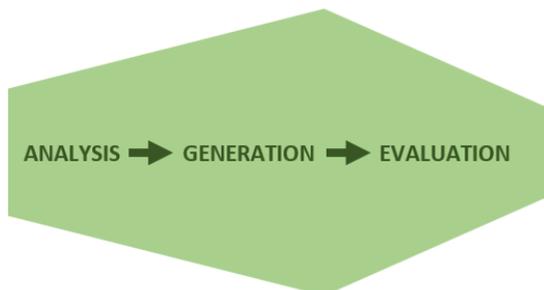
The study by Howard et al. (2008), like other authors (Brown, 2009; Fernandez et al., 2002; Thoring & Mueller, 2011), further describes the design process as a sequence of iterations of the creative process, contained within a gradually narrowing possibility space (Figure 3).

Figure 3.
The design process as an iteration of divergent-convergent creative processes within a narrowing possibility space
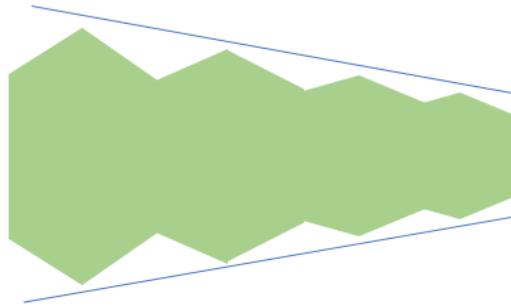
Hubka & Eder (1996) describe the design process as transformative: while students learn to design, they also learn through design. Christiaans & Venselaar (2005) explain that general process knowledge, acquired through frequent practice of the design process is correlated with improved creativity resulting from improved metacognition.

2.3.2. Product

From a psychology perspective, the creative output is an idea, while from an engineering design perspective, output refers to a finished product (Howard et al., 2008). In the educational setting, while students should be assisted to reach a finished product, ideally educators recognise and promote creative ideas, even when students are not able to translate them into finished products. Additionally, various authors discuss how a creative product is not just unique but also appropriate, relevant, and of value (Amabile, 1983; Cropley, D. & Cropley, 2010; Denson et al., 2015; Robinson, 2017).

2.3.3. Press

Rhodes (1961) defined Press as the interaction between humans and their environment, which can have positive or negative effects on creative performance. From an educational perspective, parallels can be drawn between Press and constructivist perspectives of education, particularly Vygotsky's socio-cultural perspective. In the D&T classroom, Barlex (2004) considers the design-and-make assignments as the instruments for creativity, allowing teachers to present relevant contexts.

2.3.4. Person

Person refers to the personal attributes and qualities of the creative individual. Cropley (2011) refers to a "constellation of psychological characteristics" (p. 436), while Runco (2014b) explains how emotional barriers can result from risk avoidance, fear of mistakes and ambiguity, and lack of confidence. Risk taking is considered a fundamental requirement for creativity by Barlex (2004) and Thoring & Mueller (2011).

## *2.4. Research Gap identification*

The multitude of factors that need to be considered to promote creativity, as identified in this review, mean that teaching for creativity is a complex task for teachers. It therefore seems reasonable that teachers need support to meaningfully foster creativity. This study is concerned with a triad of fields of study: D&T, Education, and Creativity. Most of the literature reviewed addresses a combination of only two of these three fields. Even literature which addressed the three of them (i.e., Creativity in D&T Education) tends to focus on a small selection of the factors discussed. This is also true for the toolkits reviewed.

Figure 4.
Research Gap identification
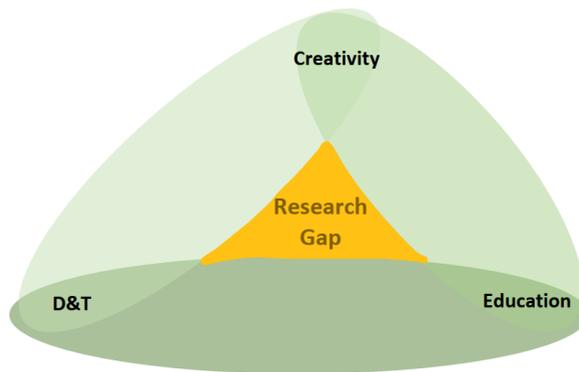
This highlights a gap in the existence of holistic guidance for teachers incorporating factors from the three major fields which can be directly employed in the classroom (Figure 4). In view of this, this research aims to address this gap by applying the knowledge acquired in this study to develop a holistic toolkit addressing teachers' needs to foster creativity through D&T education (Figure 5).

Figure 5.
A broad mapping of the knowledge from the three fields being addressed, forming the basis of the proposed solution.
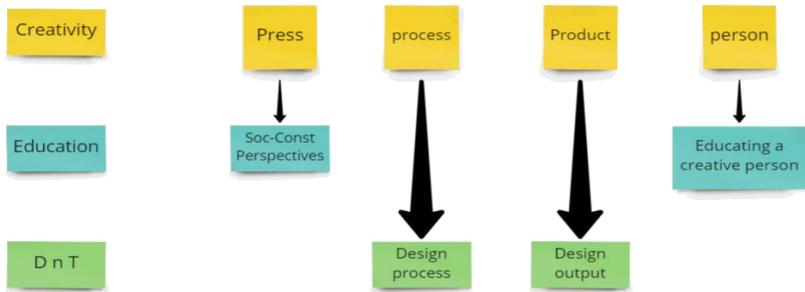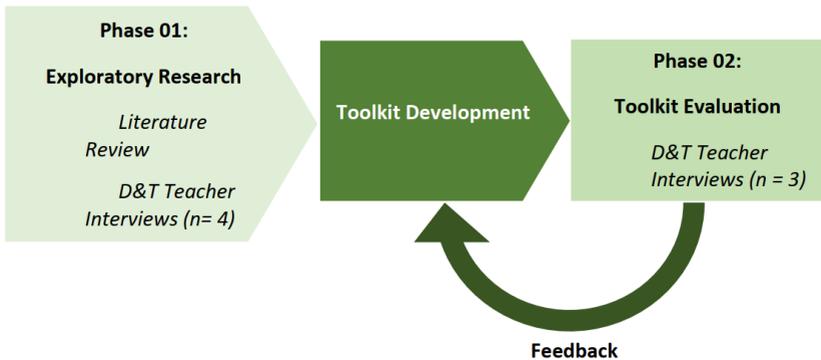

3. METHODOLOGY

3.1. Research Approach

The research process was organised in two phases (Figure 6):

Figure 6.
Organisation of the research process

3.1.1. Phase 01 – Exploratory Research

This was aimed at gathering data through the literature review, and four interviews with practising Maltese secondary school D&T educators to address the main research question. The findings from this phase were analysed inductively and translated into the development of the toolkit.

3.1.2. Phase 02 – Toolkit Evaluation

Further interviews were carried out with three D&T teachers who, based on their experience, reviewed the first version of the toolkit to assess its potential to foster creativity in D&T classes. This served as a feedback loop into the design process and, where possible, aided the improvement of the second version.

3.2. Research Methodology

A qualitative research methodology was adopted, based on constructivist theories whereby people construct meaning to interpret the world around them (Cohen et al., 2018). It was deemed appropriate since the main aim of the study was the creation of a toolkit for teachers, therefore understanding their views and needs, helped ensure the toolkit addresses their realities. Both phases make use of one-to-one, standardised, and structured interviews using open-ended questions for data collection. Questions for Phase 1 were aimed to identify teachers' definition of creativity, its role in D&T, ways students demonstrate creativity in the subject, and challenges and strategies to promote creativity. Questions in Phase 2 investigated practicality of the toolkit in the classroom, including strengths and limitations they could identify.

3.3. Sampling and recruitment

The snowball technique was used for recruitment of participants, using their social networks and contacts, to gain access to other participants. The community of D&T teachers in Malta is relatively small and close-knit, hence this technique increased the probability that a participating teacher encouraged a colleague to participate.

3.4. Data analysis

Each interview was audio-recorded, transcribed, and anonymized in preparation for the data analysis. Thematic analysis was used, following the steps recommended by Braun & Clarke (2006), and Creswell & Creswell (2018).

4. FINDINGS AND DISCUSSION

4.1. Phase 1: Exploratory Study

### *4.1.1. Defining Creativity and its links with D&T*

Initial attempts by participants to define creativity expressed the elusiveness and fuzziness expressed in literature (Fisher, 2004; NACCCE, 1999). Further attempts were related to the creative Product, especially in linking creativity with D&T. Also, while participants seemed to know the core qualities that make the subject suitable for promoting creativity, they did not express these qualities when asked directly.

To raise awareness about a holistic view of creativity, and links with D&T, the toolkit includes the following:

- A philosophy that addresses all 4Ps (Figure 7).
- Placing the design process as presented in the D&T syllabus (MATSEC, n.d., Table J), at the backbone of the toolkit design. It focuses on the first two phases (Exploration and Designing) since design freedom beyond these phases is significantly reduced (Fernandez et al., 2002).
- Using the spiral curriculum, integrating different topics within frequent practice of the design process.
- Authentic tools used in real-life design, encouraging exploration of real-life scenarios.

Figure 7.
A graphical representation of the underlying philosophy for the toolkit, integrating the 4Ps of creativity.
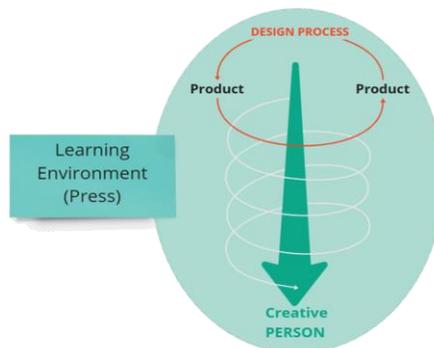
4.1.2. Factors affecting Creativity

The most prominent factors affecting students' creativity as discussed by participants were the following:

- Barriers:
    - Students' inability or lack of confidence in expressing themselves, reflecting findings in a project discussed by Barlex (2007) where students come up with more creative ideas when they knew that they did not need to make the product they were designing.
    - Creativity or design fixation, also highlighted by Barlex (2004) and Cross (2006)
- Facilitators:
    - An opportunity for students to have sensory interaction with their ideas. This mirrors the benefits of modelling and prototyping described by Pahl et al. (2007) and Thoring & Mueller (2011).
    - A learning environment and classroom climate which promote freedom, autonomy, fun and enthusiasm where students feel safe and confident to express their ideas – relatable to the 'Press' aspect of creativity (Rhodes, 1961)

These findings are incorporated in the toolkit by including:

- A section with tools addressing aesthetic and functional expression and interaction.
- Tools titled 'Parallel prototyping' and 'Flexible Modelling'.
- An 'Energizers' section for the short-term, and 'Tools for a Creative Environment' for the long-term fostering of a creative learning environment.
- Tools instigating breaking out of an initial 'frame of reference' (Akin and Akin, 1996, as cited in Cross, 2006): Reverse Brainstorming, Dark horse, Random word, and Brain writing amongst others.

4.1.3. Methods to promote creativity

The main methods used by teachers, include:

- Providing external stimuli at an ideal timing similar to findings by Zhao et al. (2021).
- Collaborative learning.

Since the methods employed varied with different teachers, it was felt that the toolkit should promote these methods to ensure all students receive homogenous education. Additionally, some methods were inspirational to the creation of the toolkit. Based on these methods, the toolkit includes the following:

- The design process as the backbone of the toolkit and the recommendation to practice this frequently to foster creative confidence (Balakrishnan, 2021; Panke, 2019);
- A recommendation that for scaffolding purposes, students are first introduced to the design process using case studies and product analysis. When gaining experience they are provided more open-ended scenarios (Figure 8).

Figure 8.
Colour coding distinguishes between case studies or product analysis scenarios and scenarios with completely new situations
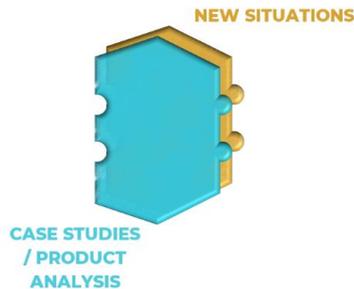
- Splitting the design process into plug-in 'modules' (Figure 9) each being the smallest part of the process. Depending on the needs, a combination of modules can be used. To expose students to the design process in a gradual manner.

Figure 9
Graphical representation of the 'plug-in modules'.

- Splitting the Designing Phase into two, with tools for the second iteration requiring external stimuli (e.g., SCAMPER and Random Word). This is also an ideal place to tap into the process if the recommendation of starting with case studies and product analysis is followed.

4.1.4. Ideas about a toolkit

When discussing the idea of a toolkit, all teachers welcomed the idea to vary their current ideas, resources and methods, but showed concern with limiting their autonomy.

To address this concern, the toolkit delivers, and explains, three layers (Figure 10):

(i)   A general philosophy addressing the 4Ps of creativity through the spiral curriculum and design process having short and long-term aims.

(ii)   The Design process itself, which is made up of iterations of the divergent-convergent creative process.

(iii)   The most superficial layer, made up of the individual tools, organised within the design process according to the previous two layers.

For flexibility, teachers are free to decide individual layers or combinations including the combination of all three. Individual tools also include references inviting further exploration.

Figure 10.
The 3 Layers of the toolkit
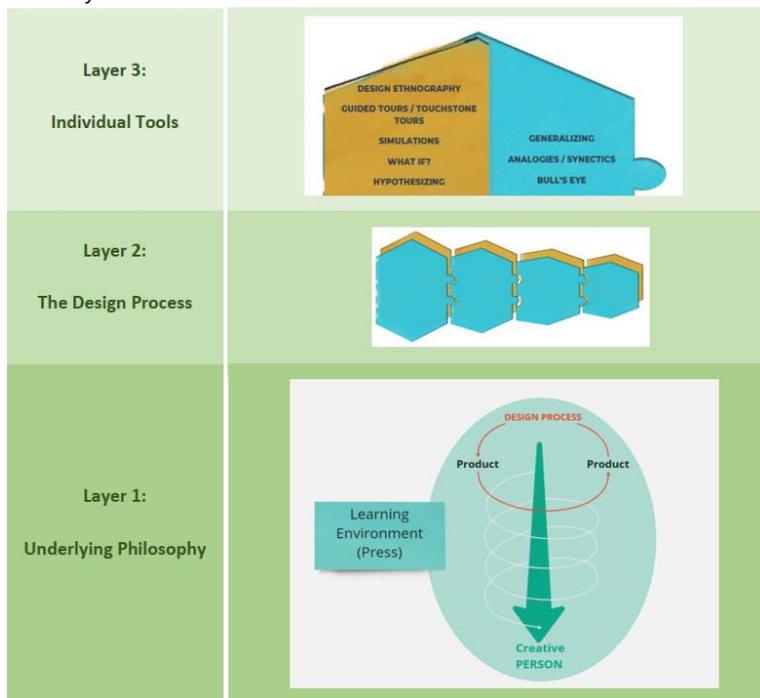
From this phase, it can be noted that while, collectively, results reflected theories and studies identified in literature, there was lack of homogeneity amongst individual participant with regards to knowledge related to creativity and methods employed to promote it. This re-affirmed the need of the toolkit as intended by this project to ensure students are given the same opportunity to develop their creative potential.

4.2. Phase 2: Toolkit Evaluation

4.2.1. Positive Factors

The main benefits of the toolkit emerging in this phase were the following :

- Helping students in research and exploration, which they seem to find difficult.
- Addressing design fixation through the design process and collaborative tools.
- Helping students to "think deeper about the design process". This highlights a distinction from Phase 1, where it can be argued that reference to thinking about the process is potentially a result of teachers having been exposed to the toolkit.

Other benefits of the toolkit pointed out by the participants were the following:

- The energisers which help set up the right environment so students feel safe and are willing to open up;
- Improved teacher awareness about creativity;
- Alternative teaching methods;
- References included in the description of specific tools;

4.2.2. Negative Factors

The negative factors mentioned were the following:

- Available time to use the toolkit and deliver the syllabus. Based on this finding, items in the toolkit were referenced to the syllabus to convey the message that it is not an addition to the syllabus but a proposed means to deliver it.
- A learning curve until full benefit from the toolkit can be obtained. It can be argued that this is outweighed by the research time that the toolkit saves in the long term.
- A factor related to the layout of the toolkit, which led to modifications in the graphical communication aspect.

4.2.3. Future Opportunities

Recommendations for future adaptations emerging in this phase were the following:

- Adapting the toolkit to be made available for students so they can have more exposure and make independent decisions
- Developing the toolkit on more mainstream media, such as a webpage or a mobile device application.
- Incorporating a feedback platform. This was in fact the idea during the initial design of the toolkit - to be shared and developed in real time in a communal environment. However, was not followed was due to time constraints at the time of development.
- Prioritising the 'Press' aspects of the toolkit as this lays the foundation of all attempts towards creativity and it would make the toolkit transferrable to other school subjects.

5. CONCLUSION

While it is not easy to define creativity, this study has shown that it has multiple facets. The 4P framework – Person, Process, Product, and Press – is used as a basis for exploration. It appears that D&T teachers focus on the Product aspect, giving less importance to the other three. This study has also shown that teachers do not explicitly state the links between D&T and creativity, while not all of them recognise the importance of the design process to foster creativity. In education, creativity is promoted by first removing the barriers and explicitly teaching for creativity. Barriers emerging from this study include difficulty in expression of ideas, and design fixation. Besides the continuous practice of the design process, facilitators of creativity include sensory interaction with ideas, an environment that supports confidence and risk-taking, and teamwork. From the literature review, there seems to be lack of guidance to teachers addressing the multiple requirements of creativity in D&T education. This was also confirmed from the interviews conducted.

To address these findings, the toolkit is based on a philosophy that addresses all 4Ps of creativity, operationalized by the design process. This process is presented as a collection of iterative divergent-convergent creative processes, and the spiral curriculum guides frequent practice of the design process. It also includes provisions for scaffolding to foster creative confidence. A collection of tools is purposefully organised within the design process depending on the relevant phase. The toolkit also includes tools and methods to facilitate idea expression and tools to foster long and short-term creative environment. Evaluation interviews of the toolkit provide evidence that it can promote the high-level thinking required for creativity.

5.1. Limitations and Future potential

Due to time constraints when developing the toolkit, the focus was primarily on the conceptual aspect, with less time invested on refinement of the graphical communication elements. Similarly the toolkit was built on a relatively basic platform. Hence there is potential for it to be developed on a platform that is more interactive and accessible, such as a webpage or a mobile device application. It can also be made more interactive such that it becomes a cooperative space for the community of D&T educators.

5.1.1. Concluding remarks

This study has highlighted the close links between creativity and design in a manner that design can be considered the embodiment of creativity. This, combined with the knowledge creation element of design and the application of that knowledge in real-world scenarios, shows that D&T education is already positioned to prepare students for the present and the future needs of the societies they are already part of.

6. REFERENCES

Amabile, T. M. (1983). *The Social Psychology of Creativity*. Springer-Verlag.

Apple, M. W. (2013). *Can Education Change Society?*. Routledge.

Atkinson, S. (2000). Does the Need for High Levels of Performance Curtail the Development of Creativity in Design and Technology Project Work? *International Journal of Technology and Design Education, 10*(3), 255-281. https://doi.org/10.1023/A:1008904330356

Balakrishnan, B. (2021). Exploring the impact of design thinking tool among design undergraduates: a study on creative skills and motivation to think creatively. *International Journal of Technology and Design Education,* https://doi.org/10.1007/s10798-021-09652-y

Barlex, D. (2004). Creative design and technology. In R. Fisher, & M. Williams (Eds.), *Unlocking Creativity A Teacher's Guide to Creativity Across the Curriculum* (1st ed., pp. 103-116). Routeledge. https://doi.org/10.4324/9780203963418

Barlex, D. (2007). Creativity in school design & technology in England: a discussion of influences. *International Journal of Technology and Design Education, 17*(2), 149-162. https://doi.org/10.1007/s10798-006-0006-x

Bozkurt Altan, E., & Tan, S. (2021). Concepts of creativity in design based learning in STEM education. *International Journal of Technology and Design Education, 31*(3), 503-529. https://doi.org/10.1007/s10798-020-09569-y

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Brown, T. (2009). *Change by design* (1st ed.). Harper Business.

Bruner, J. S. (1977). *The Process of Education*. Harvard University Press.

Christiaans, H., & Venselaar, K. (2005). Creativity in Design Engineering and the Role of Knowledge: Modelling the Expert. *International Journal of Technology and Design*

14

Education, 15(3), 217-236. http://dx.doi.org.ejournals.um.edu.mt/10.1007/s10798-004-1904-4

Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th ed.). Routledge.

Creswell, J. W., & Creswell, J. D. (2018). *Research design : qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE.

Cropley, A. (2011). Teaching Creativity. In M. A. Runco, & S. R. Pritzker (Eds.), *Encyclopedia of Creativity* (2nd ed., pp. 435-445). Academic Press. https://doi.org/10.1016/B978-0-12-375038-9.00216-8

Cropley, A. (2020). Creativity-focused Technology Education in the Age of Industry 4.0. *Creativity Research Journal, 32*(2), 184-191. https://doi.org/10.1080/10400419.2020.1751546

Cropley, D., & Cropley, A. (2010). Recognizing and fostering creativity in technological design education. *International Journal of Technology and Design Education, 20*, 345-358. https://doi.org/10.1007/s10798-009-9089-5

Cross, N. (2006). *Designerly Ways of Knowing*. Springer. https://doi.org/10.1007/1-84628-301-9

Denson, C., Buelin, J., Lammi, M., & D'Amico, S. (2015). Developing Instrumentation for Assessing Creativity in Engineering Design. *Journal of Technology Education, 27*(1), 23-40. https://doi.org/10.21061/jte.v27i1.a.2

Fernandez, M., Mistree, F., & Allen, J. (2002). On A Decision Support Framework for Distributed Collaborative Design and Manufacture. Paper presented at the *9th AIAA/ISSMO Symposium on Multidisciplinary Analysis and Optimization,* Atlanta, GA. https://doi.org/10.2514/6.2002-5496

Fisher, R. (2004). What is creativity? In R. Fisher, & M. Williams (Eds.), *Unlocking Creativity: A Teacher's Guide to Creativity Across the Curriculum* (1st ed., pp. 6-20). Routeledge. https://doi.org/10.4324/9780203963418

Freire, P. (1993). *Pedagogy of the Oppressed*. Continuum.

Howard, T. J., Culley, S. J., & Dekoninck, E. (2008). Describing the creative design process by the integration of engineering design and cognitive psychology literature. *Design Studies, 29*(2), 160-180. https://doi.org/10.1016/j.destud.2008.01.001

Hubka, V., & Eder, W. E. (1996). *Design science. Introduction to the Needs, Scope and Organization of Engineering Design Knowledge*. Springer.

Hyun-Kyung, L., & Soojin, J. (2015). Social Creativity and Design Thinking in Transdisciplinary Design Education. In R. Vande Zande, E. Bohemia & I. Digranes (Eds.), *Proceedings*

of the 3rd International Conference for Design Education Researchers (pp. 1211-1226). Aalto University School of Arts, Design and Architecture. https://doi.org/10.13140/RG.2.1.2904.6880

Keirl, S. (2008). Design and Technology Education : whose design, whose education and why? *Design and Technology Education: An International Journal, 11*(2), 20-30. https://ojs.lboro.ac.uk/DATE/article/view/Journal_11.2_RES2

Kelley, T., & Kelley, D. (2013). *Creative confidence: Unleashing the creative potential within us all*. Crown Publishing Group.

Kimbell, R., & Perry, D. (2001). *Design and technology in a knowledge economy*. Engineering Council.

Lewis, T. (2005). Creativity—A Framework for the Design/Problem Solving Discourse in Technology Education. *Journal of Technology Education, 17*(1), 35-52. https://doi.org/10.21061/jte.v17i1.a.3

Lille, B., & Romero, M. (2017). Creativity assessment in the context of maker-based projects. *Design and Technology Education: An International Journal, 22*(3), 32-47. https://ojs.lboro.ac.uk/DATE/article/view/2228/2584

MATSEC. (n.d.). *SEC 33 Syllabus (2024): Design and Technology*. MATSEC Board. https://www.um.edu.mt/__data/assets/pdf_file/0004/470398/SEC332024.pdf

NACCCE. (1999). *All Our Futures: Creativity, Culture and Education*. DfEE.

Pahl, G., Beitz, W., Feldhusen, J., & Grote, K. (2007). *Engineering Design: A Systematic Approach* (3rd ed.). Springer.

Panke, S. (2019). Design Thinking in Education: Perspectives, Opportunities and Challenges. *Open Education Studies, 1*, 281-306. 10.1515/edu-2019-0022

Rhodes, M. (1961). An Analysis of Creativity. *The Phi Delta Kappan, 42*(7), 305-310. http://www.jstor.org.ejournals.um.edu.mt/stable/20342603

Robinson, K. (2006). *Do schools kill creativity?* [Video]. TED Conferences. https://www.ted.com/talks/sir_ken_robinson_do_schools_kill_creativity?language=en

Robinson, K. (2017). *Out of Our Minds. The Power of Being Creative* (3rd ed.). John Wiley & Sons Ltd.

Runco, M. A. (2014a). Chapter 6 - Educational Perspectives. In M. A. Runco (Ed.), *Creativity* (2nd ed., pp. 171-204). Academic Press. https://doi.org/10.1016/B978-0-12-410512-6.00006-0

Runco, M. A. (2014b). *Creativity: Theories and Themes: Research, Development, and Practice* (2nd ed.). Elsevier Science & Technology. http://doi.org/10.1016/C2012-0-06920-7

Thoring, K., & Mueller, R. (2011). Understanding the Creative Mechanisms of Design Thinking: An Evolutionary Approach. *Proceedings of the Second Conference on Creativity and Innovation in Design (DESIRE '11).,* , 137–147. https://doi.org/10.1145/2079216.2079236

Tran, K. N., Kudrowitz, B., & Koutstaal, W. (2020). Fostering creative minds: what predicts and boosts design competence in the classroom? *International Journal of Technology and Design Education,* https://doi.org/10.1007/s10798-020-09598-7

Warr, A., & O'Neill, E. (2005). Understanding Design as a Social Creative Process. *C&C '05: Proceedings of the 5th Conference on Creativity & Cognition* (pp. 118–127). ACM Press. https://doi.org/10.1145/1056224.1056242

Zhao, T., Yang, J., Zhang, H., & Siu, K. W. M. (2021). Creative idea generation method based on deep learning technology. *International Journal of Technology and Design Education, 31*(2), 421-440. https://doi.org/10.1007/s10798-019-09556-y