# Proactive technical creativity: mediating and moderating effects of motivation

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ABSTRACT: This study aims to verify and to understand the effect of creative technical workshops on proactive technical creativity, while using intrinsic motivation as the mediator and moderator. Using a four-group experimental research design, results revealed that having a proactive personality was significantly positively related with students' technical creativity. Furthermore, mediation analyses revealed that the impact of proactive personality on students' inventive behaviour was simply mediated only by maintained interest and sequential mediated by triggered and maintained interest. Surprisingly, no direct significant effects ($p > 0.05$) of triggered interest on creative behaviour were found. Situational interest has only direct moderation effects. Motivation could establish significant ($p < 0.001$) and strong mediating and moderating effects between relationships. These findings provide a new perspective in understanding the intervening mechanisms underlying proactive personality on technical creativity. Motivation plays a crucial role, especially, in performance-avoidance goals and decision-making processes in technology and engineering tasks.

## INTRODUCTION

Creativity is an important influencer of the sustainable development of any organisation, e.g. scientific, artistic, educational, developmental [1]. Along with innovation, it facilitates the transformation of individual learning roles, teams and organisations into desired future levels or states [2]. Inventiveness should be a basic outcome of the creative process in technology and engineering education. Despite the inclusion of the creativity process and methods in most technology and engineering education curricula, inventive products, product improvements and the positive creativity gains after accomplishing the course seldom occur. Because of the weak performance of technology education students in creative achievements, in the 2015/16 study year at the University of Ljubljana, Faculty of Education, the Faculty was piloting an optional subject called *Creative Technical Workshops*. The subject matter aims to bridge the gap between the traditional algorithmic thinking and conformist behaviour of technology education students, and between more heuristic and non-conformist approaches to learning and acting.

To enhance the constructivist approach to technological and creative development of students, it seems important to involve students' proactive personality. Proactive personality is one personal characteristic that affects creativity [3]. Research on the influence of personality has identified specific traits that either enable or disable creativity, namely: cognitive, social, motivational-affective and clinical traits [4]. The componential model of creativity gives creativity relevant skills, e.g., nonconformity, suspending judgement, perseverance and self-discipline [5]. Research on creativity has shown the role of motivation as a key influencer on creative behaviour [4][6], especially of the fact that creativity is as much attitudinal as it is cognitive [7]. Intrinsic motivation guides students through the task for the sake of satisfaction and perceived learning value associated with the task.

For a creative idea, solution or improvement to be generated, it is often necessary to step away from environmental constraints, typical of algorithmic and conformist behaviour [6]. Intrinsic motivation along with the knowledge, technical skills and special talents, is conducive to individual creativity [4]. Research also showed that after initial motivation with technological issues (triggered interest) students failed their final projects in creativity workshops or quit the course (lack of maintained interest) [8][9]. Considering the integration of situational interest and creative achievements, it seems that motivation mediates and moderates improved creativity outcome. However, both effects vary depending on the implemented technology education context.

## PROACTIVE PERSONALITY AND CREATIVITY

Proactive personality refers to individuals' disposition toward engaging in active role orientation, such as initiating change and influencing their environment [3]. Proactive people initiate changes, take action, and persevere until meaningful change occurs in the achievement of their goals, in contrast with passive people who just adapt to their undesirable circumstances [3]. Proactive personality has been viewed as a more stable trait, and along with a high level of self-efficacy and voice behaviour, allows prompt response to a problem situation or environmental context and allows completion of required tasks [10]. Proactive creativity occurs when individuals, driven by internal motivators, actively search for problems to solve and create new theories, technologies or ideas [1]. More often this leads to finding an improvement in a process or product to improve efficiency: this is called technical creativity. Technical creativity also presents the degree to which a desirable product or process is realised [11]. For creative activities of technology or engineering students to whom a pragmatic set of values is assigned, the goal is inventiveness, which is an indispensable element of progress and that improves the quality of life [12].

Proactive creativity with its concepts such as personal initiative and voice behaviour may be crucial for the translation of creative ideas into successfully implemented innovations [2]. Personal initiative comprises a range of self-starter and persistent behaviours in terms of qualitative initiative (unprompted suggestions), quantitative initiative (extra time at work or study) and overcoming barriers (perseverance) [2]. Proactive personality may predict creativity and consequently innovation. Innovation begins with recognition and generation of novel ideas or solutions that challenge past practise and regular operating procedures [2]. Proactive creativity is internal driven and exploits situational interest as a voice behaviour predictor. Voice behaviour emphasises the expression of constructive perspectives intended to improve the decision-making process, product or organisation and enhances contextual performance [2].

Situational interest as an immediate affective response to stimuli may be increased when students perceive knowledge gaps (triggered interest) or when they create different artefacts in an active-learning classroom (maintained interest) [13]. Situational interest is much dependent on the type of goals. Not all performance goals are created equally, therefore, this may have distinct motivational consequences [6]. Performance-approach goals (trying to obtain positive judgements) and performance-avoidance goals (avoiding negative judgements) can be classified. Students most like to avoid negative evaluation and performance-avoidance goals are associated with low interest and poor performance [14]. In contrast, performance-approach goals have positive effects in some situations (traditional classes) or for some participants, mostly in higher education. Performance-approach goals seem to have positive effects on academic motivation, while promoting competence evaluation and mobilising effort in the context that emphasises normative comparisons [14].

In specific situations of high uncertainty or difficulty, performance-approach goals become less adaptive and students most likely fail to complete tasks [14]. Learning motivation is the intrinsic driver for a student. Thus, a teacher/ instructor, especially, with performance-avoidance goals learning, is advised to use a question-oriented approach to improve motivation [15]. Thus, this study focused on how students' situational interest could be *caugh*t and *held* during their participation in technology education contexts. While students work in a real-classroom with a hands-on creation project, they proactively use their knowledge and experience of past projects to provide ideas for improving the current project. This positive attitude reduces participants' resistance to change and enhances interest, learning and creativity, when working on real-world projects.

The present study contributes to a more detailed evaluation of context-effects of students' proactive personality, situational interest, and technical creativity gain concerning traditional technology classroom and creative technical classroom. The curriculum of both subject-matters enhances technical creativity, but inventive products, processes, personal initiative and voice behaviour after accomplishing technological tasks and assignments seldom occur. Therefore, the following research question will be investigated:

What influences do the technology classroom and the technical creativity classroom have on the creativity gain across technology education concepts?

Therefore, it is suggested that students learning within technical creativity workshop contexts outperform students learning and training with traditional subject-related contexts regarding their situational interest, as well as their gained creativity. Specific research objectives can be guided through the following hypotheses ($H_1$-$H_6$):

- $H_1$: Proactive personality has a positive effect on student's creativity gain.
- $H_2$: Proactive personality is positively correlated to triggered interest.
- $H_3$: Proactive personality is positively correlated to maintained interest.
- $H_4$: Triggered interest is positively correlated to maintained interest.
- $H_5$: Triggered interest has a positive effect on student's creativity gain.
- $H_6$: Maintained interest has a positive effect on student's creativity gain.

## METHOD

### Research Design, Samples and Course Format

This research was designed to measure motivation as a mediating and moderating variable between students' proactivity and their creative gain as an outcome of learning/training course. To investigate the research question two contexts were chosen on two levels, basic (low) and advanced (high) (Table 1). As a traditional technology classroom called *Technical Education*, 23 irregular students (basic level) and 42 regular students (advanced) for primary school teaching were chosen.

Similarly, as a creative technical classroom called creative technical workshops 35 irregular students (low creativity course) and 25 regular students (high creativity course) for primary school teaching were chosen, all at the University of Ljubljana. Students were aged 20-28 years. For this study, effective data were collected from 111 students.

Table 1: Overview about the used research design.

<table>
<tr><td rowspan="5">Pre-test:<br><br>Creativity test: Creative Thinking-Drawing Production (TCT-DP) form A</td><td></td><td colspan="2">Technical education</td><td colspan="2">Creative technical workshops</td><td rowspan="5">Post-test:<br><br>Creativity test: TCT-DP form B<br><br>Survey Action and me</td></tr>
<tr><td>Group</td><td>Basic technology</td><td>Advanced technology</td><td>Low creativity course</td><td>High creativity course</td></tr>
<tr><td>Allotted time</td><td>10 hours of lectures + 10 hours of laboratory work</td><td>20 hours of lectures + 30 hours of laboratory work</td><td>10 hours of interactive lectures + 10 hours of laboratory work</td><td>20 hours of interactive lectures + 30 hours of laboratory work</td></tr>
<tr><td>Subject-specific context/ content</td><td>Defined by technical education curriculum [16], 6 products were made</td><td>Defined by technical education curriculum [16], 12 products were made</td><td>Creativity course defined by authors [8], and with technical education as conceptual learning</td><td>Low creativity course + Increased number of created artefacts (25%) in laboratory + product improvement task + reverse engineering to sustain motivation</td></tr>
<tr><td>Learning form/ styles</td><td colspan="2">Frontal lectures, teacher-led instruction, hands-on laboratory work</td><td colspan="2">Frontal lectures, team/group based learning, hands-on laboratory work, reverse engineering, design-based work</td></tr>
</table>

The content of technical education subject matter is centred on Avsec [16]: introduction of students into the world of design and technology using construction sets and active learning about the surrounding area. Construction sets with a variety of drives, a description of the basic materials, key components and classification of the product by selected characteristics. Classification of elements of technical puzzles, construction of various models, use and arrangement of puzzles. Methods of development of work habits, skills and knowledge. Planning, motivation, organisation and promotion of creative technical - educational activities of students. Different working and processing techniques and engineering of paper materials, clay, artificial materials, wood, soft metals and composite materials. The safe use of machining/working tools, equipment, devices and machines. Collecting of different materials, storage and ecological aspects.

The content of *Creative Technical Workshops* subject matter is focused on Avsec [17]: to get in-depth knowledge about materials, tools, devices and machines. The use of working procedures that can teacher use in the manufacturing of means/assets, different projects in the field of design and technology (toys, games, learning aids, functional artefacts, scaffolds, props ...) for educational work in primary school. Evaluation of products created as a design-based work in primary or secondary school.

Instruments

As a pre- and post-test the Creative Thinking-Drawing Production (TCT-DP) has been used [8]. In this test, subjects take both versions of the test, one (A form) as a pre-test and the other (B form) as a post-test. Subjects complete incomplete drawings in any way they like. They may draw whatever they like and how they like: everything is permissible and everything is correct. For assessment, fourteen criteria were used, as defined by Szewczyk-Zakrzewska and Avsec [8]. The maximum score for the test is 72 points.

As a measure of course effectiveness, the *average normalised creativity gain* (CG) was calculated. The CG expressed as $\langle g\rangle$ in Equation (1), is defined as the average actual gain $\langle G\rangle$ divided by the maximum possible gain [8], i.e.:

$$\langle g\rangle = \%\langle G\rangle/\%\langle G\rangle_{\max} = (\%\langle \text{post}\rangle - \%\langle \text{pre}\rangle)/(100-\%\langle \text{pre}\rangle), \quad (1)$$

where $G$ is the actual gain and $\%\langle \text{post}\rangle$ and $\%\langle \text{pre}\rangle$ are the final (post) and initial (pre) class averages, and the angle brackets "$\langle\ldots\rangle$" indicate an average of the students taking the tests.

The *Action and me* survey included questions on demographics, self-reported grade point average as the cognitive variable and nineteen attitudinal questions with four subscales. Demographic questions covered gender, age and course level. This study adopted self-developed instrument, which considered design and technology education domain and it is based on: proactive personality descriptors proposed by DuBrin [18] (five items), triggered (four items) and maintained (five items) interest items were designed based on Hidi and Renninger [19] and perceived learning value (four items) proposed by Dixon and Christoff [20].

For the assessment, a six-point phrase completion scale was used. The new scale successfully substitutes and eliminates all limitations of the existing Likert scale. The intervals of the scale together form a continuous type, from 0 (*very* *unlikely*) to 5 (*very likely*). It does not present the mean, but ensures the comparability of continuous responses and produces better assumptions of parametric statistics while avoiding bias.

Data Collection and Analysis

Students participated in the study during real-world classroom sessions throughout a study day. The entire experiment was conducted in the 2015/16 study year. An individually or group administrated creativity test with one version takes 15 minutes. This examination (pre-test) first used version A of TCT-DP, and later used version B (post-test) version B. It should be noted that version B is a mirror image of version A. Applications can be used for screening (creativity training; as a selective instrument in recruitment to schools or vocations), in individual diagnosis and for research (studies of the nature, development and determinants of creativity and cross-cultural studies). Administration of the *Action and me* survey was performed when the learning activities of each group course had been completed. A paper and pencil survey was distributed accordingly. A large majority ($N$ = 111) of the enrolled students completed the survey.

Data analysis was conducted using SPSS v.22 and A. Hayes Process 2.16 software. To support the reliability of both TCT-DP and the survey, a Cronbach's α (alpha) coefficient was used. To support criterion-related validity of the *Action and me survey*, corrected Pearson $r_{xy}$ coefficient was used. Descriptive analyses were conducted to present the students' basic information and the average ratings of attitudinal variables. The authors conducted a two-way ANOVA to find and confirm significant relationships within and between four groups of students with an effect size calculated with $\eta^2$ (eta squared). To find mediating and moderating effects, Process 2.16 was run within SPSS.

RESULTS

The Cronbach's coefficient alpha values, based on the sample of this study, indicated that the developed and upgraded instruments are highly reliable (Table 2). Then, Pearson's correlation analyses were conducted to examine the interrelationship between the measurements (triggered interest, maintained interest, perceived learning value and creativity gain). The Pearson correlation coefficient $r_{xy}$ was calculated and high criterion validity was revealed. Inter-item correlations were all < 0.7 which suggests high criterion validity. This demonstrates that all test items are appropriately designed and constructed and each item measures exactly what it has been designed to measure.

Table 2: Reliability information Cronbach' α on *TCT-DP* and *Action and me* survey subscales.

| TCT-DP | Action and me | | |
|---|---|---|---|
| Total | Proactive personality | Triggered interest | Maintained interest |
| 0.84 | 0.81 | 0.86 | 0.90 |

Means ($M$) and standard deviations ($SD$) for the measured variables were calculated next. Table 3 depicts the average scores in the pre- and post-tests; and considering Equation (1) the normalised creativity gain was calculated.

Table 3: Pre- and post-test descriptive statistics ($N$ = 111).

| | Pre-test | | Post-test | | Creativity gain | | Number of students |
|---|---|---|---|---|---|---|---|
| Group | *M* [/] | *SD* [/] | *M* [/] | *SD* [/] | *M* [%] | *SD* [%] | *N* [/] |
| Basic technology | 28.90 | 5.90 | 28.70 | 5.93 | -1.64 | 15.18 | 20 |
| Advanced technology | 27.66 | 6.01 | 26.30 | 7.50 | -3.64 | 15.49 | 42 |
| Low creativity | 28.86 | 6.61 | 31.17 | 7.87 | 4.81 | 14.74 | 28 |
| High creativity | 31.28 | 8.62 | 40.23 | 6.78 | 19.58 | 19.10 | 21 |
| Total | 28.87 | 6.76 | 30.60 | 8.72 | 3.24 | 17.97 | 111 |

It seems that the high creativity workshop scores higher from other groups both at the pre- and post-test. The reported creativity gain was negative in the advanced (traditional) technology classroom (more algorithmic behaviour, less heuristics), while the high creativity workshop outperformed all other groups. The normalised creativity gain was around 20% and is regarded as a more effective creativity course.

Further descriptive analysis indicated that the test for homogeneity of variance was non-significant, meaning that the sample exhibited characteristics of normality required for analysis under the assumptions of the general linear model. The Levene's test for equality of variances achieved no statistical significance both at pre-test $F$ (3,107) = 1.18 ($p$ = 0.33 > 0.05) and at post-test $F$ (3,107) = 0.53 ($p$ = 0.67 > 0.05). The Levene's test confirmed that the study sample did not violate the assumption of normality, which confirmed that the sample is normally distributed ($p$ > 0.05).

A two-way ANOVA was performed to test contrasts within subjects how creative technical workshop enhances creativity in treatment groups. Statistically significant impacts were found; namely, a high creativity classroom outperforms other groups significantly ($p$ < 0.01) with an effect size of $\eta^2$ = 0.23 regarded as a high effect. Surprisingly, no significant effects ($p$ > 0.05) were found between the other three groups.

Figure 1 depicts the average ratings in the *Action and me* survey. Considering the range of 0-5 and a mid-point score of 2.5 all reported ratings were above the mid-point. It seems that regular students (ages 20-21) in the *advanced technology classroom* scored lower on all subscales compared with their counterparts. Irregular students (ages 24-28) engaged in the low creativity course perceived their proactive personality, triggered and maintained interest for technical education at a higher level. Irregular students used a lot of heuristics in their current work at primary school and their attitude towards technology is higher.

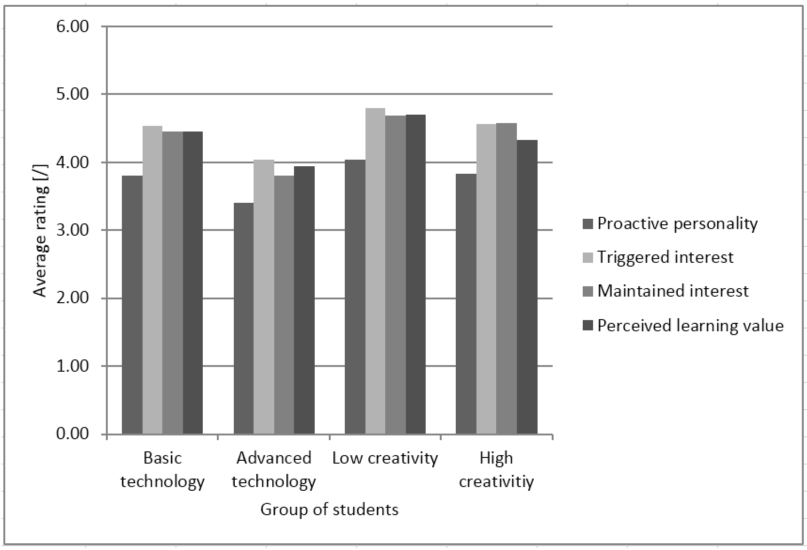


Figure 1: Students' average ratings on *Action and me* survey subscales with a mid-point 2.5.

The Levene's test across all four groups and variables surveyed confirmed that the study sample did not violate the assumption of normality, which confirmed that the sample was normally distributed ($p > 0.05$). Regression analysis was performed to see how much proactivity as the independent variable can predict student creativity gain. The results revealed that the independent variable significantly predicts student creativity gain ($F$ (1,109) = 30.84, $p$ = 0.000 < 0.05). Approximately 22% of the variance in student creativity gain was accounted for by the predictor variable (standardised β-weight = 0.47). The variances explained were calculated using $R^2$ from path model where $R^2 = 0.02$ - a small impact, $R^2 = 0.13$ - a medium effect size, and $R^2 = 0.26$ and above presents a large effect size [8].

To find both the direct and indirect effects of situational interest on creativity gain as model-derived structural hypotheses, mediation, moderation and conditional analysis have evolved as proposed by Hayes [21]. Hayes developed a plug-in for SPSS software called Process 2.16, which serves as an effective tool using a bootstrapping method. A structural model No 6 with two mediators was used [21]. For direct effect, proactivity is significantly related to triggered interest (β = 0.37, $t$ = 4.20, $p$ < 0.001); proactivity is significantly related to maintained interest (β = 0.29, $t$ = 3.94, $p$ < 0.001); triggered interest is significantly related to maintained interest (β = 0.56, $t$ = 7.70, $p$ < 0.001); maintained interest is significantly related to creativity gain (β = 0.43, $t$ = 3.70, $p$ < 0.001); proactivity is significantly related to creativity gain (β = 0.33, $t$ = 3.94, $p$ < 0.001). Surprisingly, triggered interest did not significantly predict creativity gain (Figure 2). Further, each 95% confidence interval (CI) did not include zero, which reveals the direct effect exists in this research model.

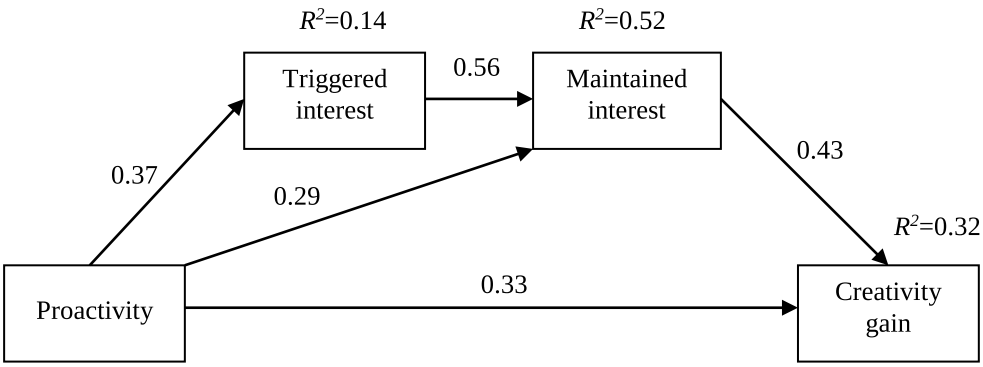


Figure 2: Mediating and moderating effects of motivation. All reported standardised path coefficients are positive and significantly different from zero ($p$ < 0.001).

For indirect effects, the results of the bootstrapping method indicated that the indirect effect of triggered and maintained interest in proactivity on creativity gain was 0.14 with 95% CI: [0.10, 0.26], the 95% CI did not include zero, revealing that there was a mediator effect for triggered and maintained interest in the relationship between proactivity and creativity gain.

To find the moderation effects of situational interest on creativity gain, structural model 2 was used [21]. A significant change in moderation was found (F (5,105) = 10.26; $p < 0.01$). Only direct moderation effects of maintained interest ($\beta = 0.43$) and proactivity ($\beta = 0.33$) on creativity gain were found. A moderation effect of interactions of triggered and maintained interest with proactivity were found not to be significant ($p > 0.05$).

## CONCLUSIONS

From the synthesis of two different context-view models of creativity development, only hypothesis $H_5$ was rejected. Triggered interest was found not to be a significant ($p > 0.05$) predictor of creative behaviour, while in contrast to learning achievements, it was found to be a single significant predictor in perceived learning value. Technical and technology education courses still suffer from creativity development, while heuristics have been evolved for irregular students.

Technology education goals should be designed from a performance-approach rather than performance-avoidance goals. Motivation as a mediating and moderating factor significantly ($p < 0.001$) affects the technical creativity gain with strong effect size (all path coefficients are > 0.26, $R^2 = 0.32$). Future research is needed to design a framework for systematically increasing and measuring technical creativity in technology and engineering education. Proactive creativity should be further studied to find how an open problem-oriented approach can facilitate student's situational awareness. There must be more work to develop more precise definitions and operationalisations of goals, motivational orientation and extrinsic rewards considering individual environmental impacts.

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