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Attitudes and perception of future teachers toward design and technology

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ABSTRACT: This study was an investigation of whether students' attitudes to design and technology significantly predict creative ability and perceived learning value in future teachers. A 4-level experimental design was used. An effective sample of 131 pedagogy students was collected from the University of Ljubljana, Slovenia. Only high creativity courses enhance students' creative thinking significantly ($p < 0.05$) with a large effect size ($\eta^2 = 0.22$). It seems that technology education itself did not affect creative behaviour in future teachers. Perceived learning value of technology courses was regarded as high in a majority of cases. Students' attitudes towards design and technology were found to be significant ($p < 0.01$) predictors of creativity gain ($R^2 = 0.32$) and of perceived learning value ($R^2 = 0.25$). Awareness of the consequences of technology was found to be the most positive predictor of creativity gain, while the use of heuristics (practical intelligence) was found to be the most positive predictor in perceived learning value. The results of the study suggest student motivation and goals can be influenced by adapting instruction accordingly.

INTRODUCTION

In a rapidly changing technological world, the need to be technological literate is much in demand [1]. Technological knowledge seems not to be sufficient to cope with technology current needs, and an inclusion of affective, conative and evaluative (meta-cognitive) domain is required [2][3]. Students' attitudes and self-efficacy seem to be the key mediator in the learning process [4] when subject matter knowledge, pedagogical content knowledge, and attitude to, and perceptions of, technology have a positive effect on student learning outcomes [5]. Thus, a student's willingness to take responsibility for their success or failure might be increased [4].

Moreover, teachers' attitudes to technology, creative ability and confidence in teaching design and technology are an important influencer of students' attitudes to technology and students' creative ability. Creative ability is the most important ability in today's technology-intensive world [5][6]. Low confidence in teaching design and technology, and negative attitudes to technology are very often reflected in the classroom as low self-efficacy with a lack of self-motivation [4]. Advances in technologies have changed people's values, aspirations and the way they work. Problems, which need ingenuity, imagination and creativity were generated [6]. Technology education prepares students to understand and participate in a technological society. Students' engagement in technology education could improve their perceptions of technology [3].

The Faculty of Education at the University of Ljubljana has a long tradition in teaching/training future teachers both for primary and secondary schools. Teaching design and technology seems to be demanding, due also to the heterogonous nature of the learning outcomes. Moreover, when the course has ended, students must be able to know, to do, to manage technologies, to understand, to think critically and to be able to make decisions, and to be more creative, as a part of course competencies. However, in an actual technology and engineering classroom, a disparity is often reported, when creativity goes up, cognitive learning outcomes go down and *vice versa* [1][7][8]. In teaching design and technology, a criterion-based design is utilised, with a lot of hands-on laboratory work, but still teacher-led laboratory work. Beside this, an assessment of students' products and artefacts is focused on a gradually obtained criterion level through step-by-step laboratory and project-based work. Yet, the impact of self-efficacy on student satisfaction and perceived learning value, as course quality characteristics, is scarce and inconclusive for high school and university education [4]. Therefore, one can be concerned about a hypothetical model in which student attitude towards design and technology perhaps relate to students' creativity and perceived learning value of the course.

Students' Attitudes to Design and Technology

Students' attitudes are important concepts for understanding their thoughts, processes and classroom practices. There are many definitions of attitude in general. Attitude can be described as a mental and neural state of readiness, organised through experience, exerting directive or dynamic influence upon the individual's response to all objects and situations with which it is related [9][10]. Technology is now pervasive and attitudes to technology play an important role. Psychology defines the concept of attitude as an internal, personal, psychological tendency to evaluate an object or construct in a positive or negative manner [11]. Young people are interested in technological products, although their opinion about studying technology and engineering jobs is rather negative. Moreover, people think that technology is hard and boring to study, industrial environments are not interesting, and technical labour is hard and dirty [2]. It has been shown that students with a positive attitude to technology have a higher interest in technology. Attitude to technology is a multidimensional construct. Yu et al defined a model which consists of interactive categories of: interest in technology, feeling perplexed by technology, identification with technology, experiences with technology curricula and as a goal pursuit of careers in technology [3]. De Vries defined five categories of attitudes to technology: interest in technology, aspirations for a technological career, perceived consequences of technology, perceived difficulty of technology and the student's perception of technology as a subject suitable to both genders [10].

Several characteristics could have a significant influence on attitude: sex, age, presence of technological toys and context. Research on attitudes to a career in technology and engineering finds that female students do not have a positive attitude to technological study or technological jobs. Besides that, female students also see science as containing difficult subject matter. From the age of 10, the level of interest in technology starts to decline, especially for females. Technological toys seem to have a positive effect on attitudes to technology, because they stimulate aspirations for a technological career [2]. An important factor in building a positive attitude to design and technology is the teacher. Teachers who perceive technology as being tedious spend less time discussing and teaching these topics in their classrooms. They use traditional methods and top-down instruction and they are not able to stimulate students' attitude [11]. Motivation seems to be a heavy component of creativity, both extrinsic (rewards, teacher effect) and intrinsic (feelings, opinions, inclination to action, response to changeless and other stimuli) [7].

Perceived Learning Value

Individual perceptions to technology and technology education outcomes are dependent on several factors, including a person's background, the amount of study, their reflection about technology and personal experiences with technology [8][12]. Some students have wrong perceptions of what technology is comprised of, but they agree that they could not live without technology [12]. Designing technology and engineering subject matter activities can appear to be problematic because learners may generate wrong solutions. However, a wrong solution may be viewed as a productive failure [13-15], that is, initial problem-solving activities can be effective even though invented solutions to problems are often suboptimal [16]. As a meta-cognitive effect, problem-oriented learning can affect motivational states [16]. For example, Avsec and Kocijancic found that an open learning design and technology programme was positively affected by hands-on activities used in the classroom [17]. In addition, Avsec and Jamšek found that laboratory design has an impact on students' attitudes to technology and engineering laboratory learning [1]. As such, the course is designed to motivate hands-on creation, thus, a course may pave the way to increasing students' learning value.

Crucial students' learning experiences, which encompass perceptions of learning outcomes/value are focused on four categories: obtaining advanced technology knowledge to solve problems, meaningful learning, extension of acquired knowledge beyond instructions and area of technology/engineering and engagement in deeper learning [4][17]. Students' positive perceived value is an important indicator of the quality of learning experiences [4]. It is worth investigating student perceived learning value in technology classrooms, because new technologies have altered the way students interact with instructors and classmates and manipulate raw material at the same time. The quality of learning in a technology classroom may depend on the technology tools utilised during learning [4]. Lack of confidence in using different technologies or engineering processes may decrease students' perceived learning value during instruction and, in turn, lower their performance. The nature of design and technology subject matter learning demands greater responsibility on the part of learners. Students who are unable to regulate learning/training efficiently are unlikely to be satisfied and their perceived learning value will be lower [4].

In most technology and engineering curricula, creativity plays a central role, due also to the fact that creative ability enhances inventiveness in students [18]. There are many definitions of creativity. Creativity is the generation of new ideas or new ways of looking at existing problems and seeing new opportunities. The creative process could be described as a sequence of thoughts and actions leading to novel and adaptive productions [19]. Creativity is the process leading to a new creation that is utilitarian or needed by a group in a certain period [16]. Students' creative ability and learning achievements might also be affected by teachers. Creativity is an important factor in students' capacity to solve problems, develop research skills and to improve their critical thinking, and decision making ability [8]. Some people have the qualities of a creative person; others had to train in creative thinking. However, everyone can improve their creative potential [2] and create something new and solve the problems of everyday life [16]. Psychologist Sternberg argued that creativity is related to a person's intelligence, knowledge, thinking styles, personality, motivation and environmental context.

Motivation is a basic requirement for a product designer [20]. The environmental context could encourage or quell creativity. A key attribute of creativity is knowledge, but designers' knowledge and experiences alone are not enough. Designers/creative persons need to go beyond their knowledge. In addition to the knowledge, the most important attribute is a thinking style as a psychological category. For a creative person, it is not enough to follow the habitual thinking style. He/she must seek new ways to solve problems beyond his/her usual thinking style. There are different methods which increase creativity, such as brainstorming, inventive problem-solving (TRIZ, CT) [20]. The success of designers and engineers is not only dependent on a formal or explicit knowledge, but also on inexplicable or implicit knowledge, so important in technology and engineering disciplines. Szewczyk-Zakrzewska noted that classified information is essential for the creation of tacit knowledge, which is crucial for ingenuity and the development of humans' creative attitude [18]. She highlighted four domains of creativity, which differ according to the type of activity and predominant purpose: cognitive values are aimed at discovering, investigating and learning; aesthetic values define shape or design of the object or concept; pragmatic values are aimed at usability and associated creativity enhances inventiveness; and ethical values which consider the public domain as creative activity [18].

In higher education, instructors must strive to follow teaching approaches and pedagogies that foster students' construction of their knowledge through inquiry, exploring, explaining, modelling and finding solutions to problems. The instructor's role is to make constructive use of students' prior knowledge, encouraging the discussion of alternative viewpoints, and helping students to make connections between their ideas and relate these to important scientific concepts and methods [17]. Intellectual operations of abstraction, metaphorical thinking, making associations, inductive and deductive reasoning, and transformation with reverse engineering seem to be the basis for creative thinking processes [18].

A combination of utilisation of cognitive mechanisms, subject matter content and process, eliciting students' positive attitudes toward technology along with a proactive behaviour might increase creative gain and improve perceived learning value.

Research questions explored in this study are:

- What is the attitude of pedagogy university students to design and technology?
- How do students' attitudes to technology affect their creativity gain and perceived learning value?

METHOD

Research Design, Samples and Course Format

The sample in this study comprised 131 university students aged 19-39. Classroom activities were carried out in the Faculty of Education at the University of Ljubljana. Students attended real-classroom activities where a 4-group research design was used. A creativity course was conducted in two experimental groups; namely, a *Low technical* creativity course (N = 30) and a *High technical creativity* course (N = 23), contrasted with two control groups; namely, a *Basic technology* course (N = 20) and an *Advanced technology* course (N = 58). For all these groups, the courses were presented as lectures and laboratory work. There are differences in the amount of time devoted to lectures and laboratory work. The *Basic technology* and *Low creativity* course were provided for irregular students. There were 10 hours of lectures and 10 hours of laboratory work. On the other side, the *Advanced technology* and *High creativity* courses were presented for regular students via 20 hours of lectures and 30 hours of laboratory work. Differences were found in the strategies and methods used. The *Basic technology* and *Advanced technology* courses were predominantly frontal lectures, with teacher-led instruction and hands-on laboratory work. Whereas in the *Low creativity* and *High creativity* course, team/group based learning, hands-on laboratory work, reverse engineering and design-based work methods were used.

Instruments

For measuring students' attitudes to technology, a reconstructed 25-item test of the Students Attitude to Technology was used [10]. The *Technology and me* questionnaire included questions on demographics (sex and age), and eight questions about family background and home education background. These 25-items covered six constructs: 1) technological career aspirations (TCA) - four items; 2) interest in technology (IT) - six items; 3) tediousness to technology (TTT) - 4 items; 4) technology across the sexes (TS) - three items; 5) consequences of technology (CT) - four items; and 6) technology/engineering study is difficult (TD) - four items. For the assessment, a 5-point Likert scale was used. The intervals of the scale together form a continuous type, from 1 (very unlikely) to 5 (very likely). For measuring perceived learning value (PLV), four test items were designed as a part of the *Action and me* survey. For the assessment, a 6-point phrase completion scale was used. The intervals of the scale together form a continuous type, from 0 (*very unlikely*) to 5 (*very likely*). Creativity of students was surveyed with standardised test of creative Thinking-Drawing Production (TCT-DP) [21]. Students completed incomplete drawings in any way they liked. Fourteen criteria were used provide an assessment [21]. Maximum score on the test is 72 points.

Data Collection and Analysis

Students participated in the study during real-world classroom sessions throughout a normal study day. The entire experiment was conducted in the 2015/16 academic year. Students were surveyed by using the paper and pencil method.

The *Technology and me* test was performed before the learning activities of each group, and the test for measuring students' perceived learning value was performed after learning activities of each group. TCT-DP was performed twice, before learning sessions and after learning sessions. Individual testing for each test takes 10-15 minutes. The data were analysed with IBM SPSS (v.22). To support the reliability of tests, a Cronbach' alpha coefficient was used. For a criterion-related validity of the same test, the corrected Pearson r_{xy} coefficient was used. Besides that, the basic tools of descriptive statistics, two-way ANOVA and multiple regression analysis, were used.

RESULTS

The Cronbach's coefficient alpha values based on the sample of this study indicated that the development instruments are highly reliable, with all Cronbach's alpha values being > 0.60 (Table 1). Pearson correlation coefficient r_{xy} revealed high criterion validity. Item correlations were all < 0.7 which indicates high criterion validity, a situation that demonstrates that all test items are appropriately designed and constructed, and that each item measures exactly what it was designed to measure. Evidence of the high reliability of TCT-DP test was provided with Cronbach' $\alpha = 0.84$.

Table 1: Reliability information Cronbach' α on surveys subscales.

Subscales	TCA	IT	TTT	TS	CT	TD	PLV
Cronbach' α	0.88	0.83	0.85	0.87	0.79	0.71	0.89

Further descriptive analysis indicated that the test for homogeneity of variance was non-significant ($p > 0.05$), meaning that the study samples are normally distributed. The Levene's test for equality of variance achieved statistical significance in neither the creativity pre-test $F(3,107) = 1.18$ ($p = 0.33 > 0.05$) nor in the creativity post-test $F(3,107) = 0.53$ ($p = 0.67 > 0.05$). A two-way ANOVA was performed to test within subject contrasts how different applied methods enhance creativity in each of the four groups. Statistically significant effects of learning were found $F(3) = 11.94$ ($p = 0.00 < 0.05$) with a strong effect size $\eta^2 = 0.26$. A two-way ANOVA was performed to test between subjects: how do creative learning activities enhance creativity in the treatment groups? Statistically significant differences ($p < 0.05$) were found between the groups. The *Scheffe* post-hoc test found statistically significant differences ($p < 0.01$) between the *High creativity* classroom and other groups, with an effect size $\eta^2 = 0.22$ regarded as a strong effect. No statistically significant differences ($p > 0.05$) were found between the other three groups.

Figure 1 depicts the average creativity scores for each group participated in this study. Average scores from pre-test and average scores from post-test are shown. It is evident that the progress in creativity was made in the *Low creativity* group and the *High creativity* group. A slight decline in creativity was detected in the *Basic technology* group and the *Advanced technology* group. It seems that technology classes develop more algorithmic and conformist behaviour. Students' design and technology activities are mostly criterion-related or as teacher-led instructional laboratory work.

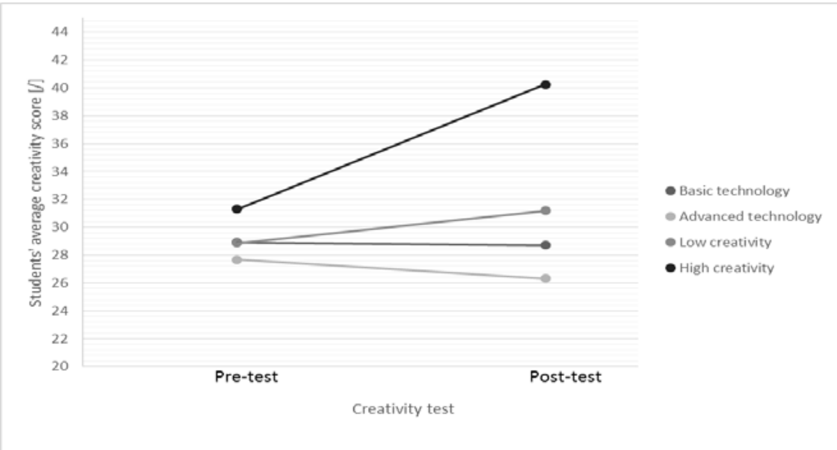

Figure 1: Students' average scores at pre- and post-test of TCT-DP.

Figure 2 depicts students' attitudes and perceptions of technology within different groups, classified into seven subscales. Students' attitude to interests in technology was above average. The *High creativity* group's attitude was the most above the average (4.07 score), followed by the *Low creativity* group (3.87 score), *Basic technology* (3.77 score) and *Advanced technology* group (3.24 score). University students who have already selected their future career participated in this study, and it was expected that students would not have a positive attitude to an engineering and technology career. Besides that, students perceived the considerable importance of technology and are aware of the consequences of technology. Students do not agree that technology is only for males, and most students labelled technology as not difficult, probably because they did not have good awareness of the definition and domain of technology. Students who developed a positive attitude to design and technology gained more perceived learning value. All students' perception to technology was above average. *Low creativity* group's (4.69 score) and *Basic technology* group's (4.45 score) perception to technology was probably the most above the average, because students already have experience and some technology knowledge. Surprisingly, students in the *Advanced technology* course gained the least (3.94 score) perception to technology.

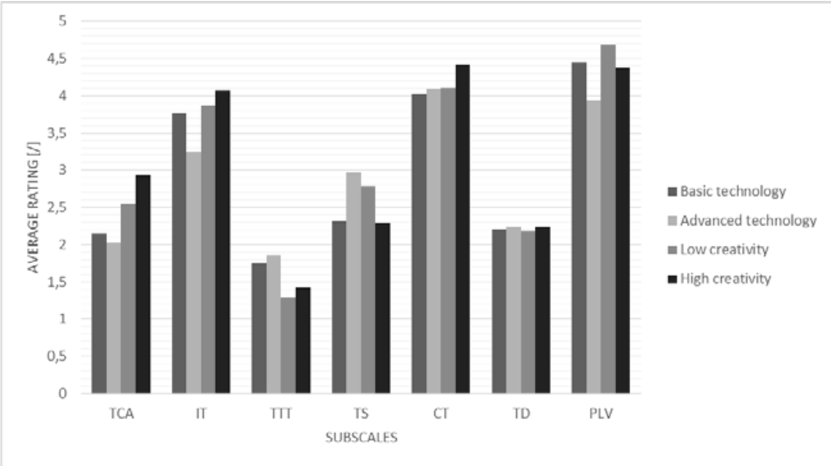

Figure 2: Students' average rating on attitude to technology with a mid-point 3, and students' average rating of perceived learning value with a mid-point 2.5.

Levene's test across all four groups and the variables surveyed confirmed that the study sample was normally distributed ($p > 0.05$). Multiple regression analysis was performed to see how much the independent variables could predict students' creativity and perceived learning values. A multiple regression analysis was carried out, with the items of students' attitudes and age as independent variables, and creativity gain and perceived learning value as dependent variables. The authors assumed a linear relation between independent (predictor) and dependent (criterion) variables, meaning that one would expect that increases in one variable would be related to increases or decreases in another. Only regression coefficients (β-weights) with a significance of $p < 0.05$ were considered. Beta (β) weights describe the relation between a predictor and a criterion variable after the effects of other predictor variables have been removed. They range from -1 to 1 (0 means no relation at all; 1 or -1 mean that variations in one variable can be explained completely by variations in another). When interpreting results, one must keep in mind that multiple regression does not explain causes and effects but instead describes relations between variables or sets of variables. A summary of the multiple regression analyses is shown in Figure 3.

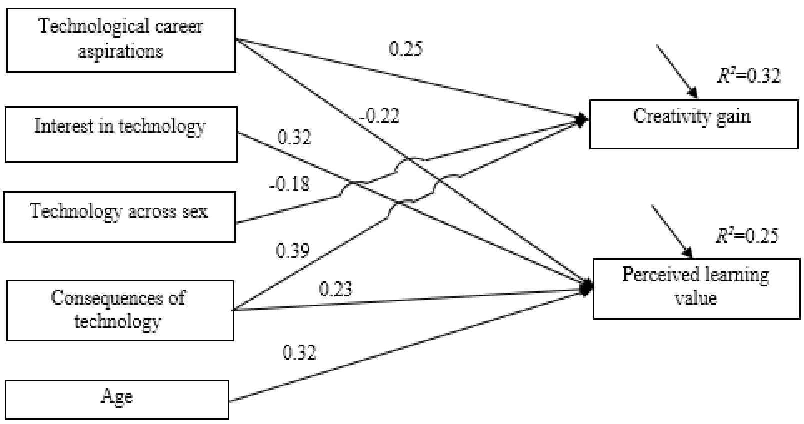

Figure 3: Students attitude toward technology regressed on creativity gain and perceived learning value. All reported standardised weights are significantly different from zero ($p < 0.01$).

Students' attitude to a career in technological and engineering jobs significantly ($p < 0.05$) predicts creativity and perceptions. Students who are highly interested in technology, perceived higher learning value when a course was accomplished. Students who perceived importance of technology as being high and considered the consequences of technology to be especially important, are more advanced in creativity and they experienced higher levels of achievement. Students' age has a positive effect on the perceived learning value. Some students ($N = 50$) who participated in this study were irregular students. They are older, most of them already have jobs and they have more experience than regular students. Regarding design and technology subject matter, it seems that they use heuristics more often in their learning.

Students with high technological career aspirations perceived the learning value of the course to be small. Perhaps these students had high expectations of the design and technology subject matter and they might be more sensitive to perceptions of course learning value. This revelation points to the likelihood of changes to some of the didactic material and methods when the course is next conducted. Students, who perceived design and technology as a male domain, advanced less in creativity. The explained variances were calculated using R^2 from the path model wher $R^2 = 0.02$ means a small impact, $R^2 = 0.13$ means a medium effect size, and $R^2 = 0.26$ presents a large effect size [7].

CONCLUSIONS

The study presented in this article revealed that students' interest in design and technology is above average. It was expected that students would have a negative attitude about engineering jobs, because they had already chosen their future career. Students are not resistant to technology and disagree that technology is only for males. Students are aware of the consequences of technology and perceive technology as being important. Their perceptions to technology are above average. In addition, the survey showed that students' attitude to design and technology significantly predicts their creativity and perceptions.

Students with a high interest in technology and experienced students perceived a higher learning value. Students' awareness of technology has a positive impact on creativity gain. Students who are interested in technology and who considered technology as important advanced more in creativity. Results suggest the need for improvements to content material, the use of active methods in technology education and changes in the teacher's role as a motivated mediator. For future work, it could be interesting to investigate attitudes to technology, creativity gain and perceptions between future teachers and engineering students. It will be interesting to find the relationship between perceived learning value and creativity.

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