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The relationship between student attitudes towards technology and technological literacy

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ABSTRACT: Technological literacy is significant for the innovation-driven economy. Students' attitudes towards technology was for a long time considered a measure of technological literacy, but evidence on interaction with technological literacy components is still lacking. Moreover, students' attitudes are formed by a variety of direct and vicarious means. For the purpose of this study, a sample of 180 secondary school students was used for empirical research. The findings suggest that the students' interest in technology and the perception of the effects of technology are the best positive predictors of technological literacy, while traditional craft-based work and skills are the most negative predictors. This might reflect tediousness toward technology, perceived difficulty of technology or a weak aspiration for a future career in technology and engineering. The findings from this study provide a deep insight into technological literacy and the need to recognise individual teachers' critical influence in the classroom.

INTRODUCTION

The outcomes of technology education (TE) reflect the knowledge, abilities and skills on the use, handling and evaluation of technology, which is a measure of technological literacy (TL) [1]. In order to achieve the TL required by a competitive market it is necessary to develop curricula for teachers of technology to increase the TL of students. For students, it is important that they are technologically literate to be able to participate in today's high-tech society [2].

Several studies of students reveal that those with a higher TL have a more positive attitude toward technology [2] and are inclined to choose careers in engineering and technology [3][4]. Many researchers investigated TL in middle school technology and engineering education, and found that more advanced TL is positively related to students' learning, motivation, and interest in technology and engineering education [3][5][6]. It is important that TE provides all students with an equal opportunity to attain reasonable TL. Interest in technology arises early in childhood [7][8]. Research has measured students' interest, motivation and attitude towards technology, which was considered a measure of TL [9]. However, TL is holistic with a number of sub-constructs of knowledge, skills and abilities involved in problem-solving, critical thinking and decision making.

Primary school technology education (K-9) in Slovenia is two-tiered. At the elementary level (K-5) technology education is part of an integrated learning domain called natural sciences and technology. At the lower secondary level, design and technology is a compulsory subject for grades six to eight (ages 12-14) and is covered by 140 school periods of 45 minutes each over all three grades. The design and technology curriculum comprises four interconnected areas; namely, technical assets, technology for processing materials, work organisation and economics [10].

Design and technology within the school curriculum requires students to demonstrate their declarative and procedural cognitive knowledge (knowing *that* and knowing *how*) and meta-cognitive knowledge (knowing *why*) [11]. A majority of benchmarks are positioned within the first three levels of the revised Bloom taxonomy: to know, to understand and to apply [10]. Higher-order thinking skills related to design and technology are seldom covered. During the past two decades no significant changes have been made to the structure and content of the design and technology curriculum to enhance abilities entailing action, criticism, informed decision making, evaluation and management. Inappropriate design and technology benchmarks and their implementation in the classroom could undermine the level of TL, which is crucial to enable students to choose a future technological or engineering career [7][9].

In this study, the authors investigated factors (i.e. technological career aspiration, interest in technology, technology and gender, tedium and technology, effects of technology and the difficulty of technology) associated with students' attitudes towards technology and their predictive value for TL.

The following research questions guided this study:

1. What is the level of TL of sixth and eighth grade students across the dimensions of TL?
2. How does students' TL reflect the Design and Technology subject matter and correlate with students' attitudes toward technology?

This will help to understand the differences in levels of TL of students studying design and technology in lower secondary school. Moreover, a predictive study will provide more insights into TL through the TE curriculum.

THEORETICAL BACKGROUND

The concept of TL appeared in the late 1970s as a descriptor for something that includes the knowledge and skills necessary for functioning in an innovative society [12]. At the time, TL was mostly concerned with understanding the world of technology used for such things as documentation [10]. A substantial shift towards the concept of critical TL occurred in 1983 [10]. Today, a person is considered technologically literate, if they understand the nature of technology, are able to interact with the technology and to think critically about issues surrounding the technology [9].

The ITEEA (International Technology and Engineering Educators Association) contextualised TL as an ability to map and assess interrelationships between technology and people, society and the environment [1]. Technological literacy is defined as the individual's ability to use, manage, judge and understand technology [1]. It consists of complex components: knowledge, capacity, critical thinking and decision making [1][5]. These are interconnected, and create additional synergies [3].

In the Slovenian lower secondary school, TL has had a one-dimensional focus on technological knowledge. It was seen as a complement to other technologies that students acquire in primary and elective courses in TE [10]. This complementary nature means that TL is not developed as part of the curriculum of TE, but simply assists the technology which students learn [10]. In TE students develop basic skills (communication, participation, evaluation, working with tools and machinery), thinking (convergent, divergent) and personality traits (motivation, concentration, precision, efficiency) [13]. In technology and engineering classes, learning takes place through direct experiential learning, hands-on experiences carried out in training workshops and school laboratories [14], where design thinking can be applied for effective problem solving [15].

Over time, TE developed from *Teaching for Production Work,* which supplements manufacturing practices to contemporary TE, where the emphasis is on TL. This shift was the result of new findings and models of effective teaching and learning in TE, as well as the need for a holistic development of students' competencies and skills to meet the challenges of modern society [10]. The reforms of national education are focused on academic achievement, while the fastest growing occupations require additional education to acquire the necessary technological skills. The requirement for technology education is that effective ways are found to achieve these goals [10]. Many researchers argued that the focus cannot only be on technological advances. Also required is the parallel development of capabilities to judge the technology, and the relationship between the individual technologies that arise in everyday life [16].

The authors view the TE curriculum as not sufficiently covering many areas of TL. For example, the technology of food production, biotechnology, medical technology, construction technology and environmental technology are not covered in the existing TE curriculum, while the development of economic and entrepreneurial competencies, transportation and production technologies are unsatisfactory [10].

The focus for students in the design and technology subject is teacher-centred, limited by textbooks and kits with semi-prepared materials. An important aspect is the motivation of students, which differs from student to student. The general aim of the design and technology subject states that students should develop a positive and critical attitude to technology. The professional interests of students should also be developed as a result of the design and technology subject [7]. The technology and engineering curriculum needs to reflect the nature of engineering practice, which requires investigation, modelling, design, management and impact assessment [17]. Technology and engineering curricula can employ many active learning methods, e.g. problem-based learning, project-based learning, critical thinking, inquiry-based learning and the real-life context of practices [18]. These active learning methods might increase self-directed learning, but effects on TL and attitudes toward technology for individual students vary substantially [10][13][19].

Various direct means for developing students' attitudes towards technology have been suggested, to:

- create more opportunities for girls to participate in technology;
- avoid gender discrimination and stereotyping;
- improve the content knowledge of technology teachers, especially pedagogical content knowledge;
- modify the nature of curricula through up-to-date material and methods of teaching/learning;
- change programmes to be more innovative and less craft- and skills-based;
- make the learning experience more student-centred [13].

Students' attitudes are formed by direct and vicarious means. It has been found that students generally have a positive attitude toward technology even though they have only a limited concept of technology. Their attitude towards technology may be attributed to various determinants or predictive characteristics [13]. Yet research on attitudes to technology in conjunction with TL is still lacking. Here the assumption is that there is a correlation between attitudes towards technology and TL.

METHODOLOGY

Sample

The sample size was 180 participants in total (n_t = 180). Students were chosen from schools in municipalities in various parts of Slovenia. With the permission of parents and assistance of teachers who agreed to have students participate in the study, tests were distributed. The sample was divided into two groups; namely, pupils who started 6th grade (n_6 = 86) and pupils who started the 8th grade (n_8 = 94) of primary school. There were more males (n_m = 92, n_{m6} = 47, n_{m8} = 45,) than females (n_f = 88, n_{f6} = 39, n_{f8} = 49). Sixth-grade respondents were mostly between the ages of 11 and 12, while 8th-grade respondents were between 13 and 14. The sample was representative of the population. Any aptitude interactions that may be present could provide a key to improving the research instrument.

Research Instrument

Given the multifaceted nature of TE outcomes, an holistic measurement has been used [3][5][10]. The TL assessment consisted of 35 multiple-choice items. The test was subdivided into three subscales based on subject matter (explicit and implicit) of the TL dimensions. The instrument consisted of 11 test items related to TK dimensions, 12 items for the TC dimension (technological capacity), and 12 items for the TCM (technological critical thinking and decision making) dimension of TL. A maximum score on the test was 35 points (100 %).

For surveying this group of students' attitudes towards technology, a reconstructed 25-item test of pupils' attitude toward technology (PATT) was used [20]. The survey entitled *Technology and me* consisted of two groups of questions. The first part focused on background data about the student (sex, student grade, curriculum, technology at home, the educational level and professions of the parents). The second part was the revalidated PATT survey [20].

For the assessment, a 5-point Likert scale was used, which measures six aspects of attitude towards technology:

- technological career aspirations (TCA) - 4 items;
- interest in technology (IT) - 6 items;
- tediousness of technology (TTT) - 4 items;
- technology and sex - differences (TS) - 3 items;
- effects of technology (CT) - 4 items;
- difficulty of technology (DT) - 4 items.

The scale goes from 1 (*very unlikely*) to 5 (*very likely*).

The Cronbach's alpha coefficient values indicated that the instrument was reliable (see Table 1). All Cronbach's alpha values were > 0.60 [3].

Table 1: Reliability using Cronbach's α on *Technology and me* survey subscales.

Scale (subscale)	Cronbach's α	Number of items
Technological literacy (total) - TL	76.3	35
Technological knowledge - TK	68.3	11
Technological capacity - TC	62.2	12
Critical thinking and decision making - TCM	60.7	12
Technological career aspirations -TCA	90.1	4
Interest in technology -TI	74.3	4
Tediousness of technology -TTT	71.1	4
Technology and sex differences -TS	87.4	3
Effects of technology - CT	76.9	4
Difficulty of Technology - DT	70.9	3

Procedure and Data Analysis

Students participated in the study during real classroom sessions. The TL test takes 30-35 minutes; the *Technology and me* survey was applied after the TL test and takes 10-15 minutes. A large majority (n = 180, 94.7%) of the enrolled students completed both surveys (missing n_m= 6, 5.3%).

Data analysis was conducted using SPSS v.22. Descriptive analyses were conducted to present the student basic information, and the mean score of dependent variables. The authors conducted ANOVA and multivariate analysis of covariance to find and confirm significant relationships with an effect size calculated with eta squared. Multiple regression analyses were performed to investigate whether predictor variables significantly predict TL dimensions.

RESULTS AND DISCUSSION

The first objective sought to describe the relationship between two groups of students at different stage of the TE curriculum, i.e. the 6th grade versus the 8th grade. Table 2 shows the average scores on TL and its dimensions, where M is mean, SD is standard deviation and n is the number of students.

Table 2: Descriptive statistics for TL and its dimensions by grade.

TL	Grade	Sex	M (%)	SD (%)	n
TL total	6th	Male	29.60	9.92	47
		Female	30.91	9.98	39
	Total		30.19	9.91	86
	8th	Male	36.01	11.12	45
		Female	32.07	9.03	49
	Total		33.95	10.26	94
TK	6th	Male	44.68	17.76	47
		Female	52.44	14.34	39
	Total		48.20	16.67	86
	8th	Male	54.14	17.95	45
		Female	51.02	18.02	49
	Total		52.51	17.99	94
TC	6th	Male	25.17	10.87	47
		Female	22.43	10.12	39
	Total		23.93	10.54	86
	8th	Male	28.70	11.02	45
		Female	24.48	10.24	49
	Total		26.50	10.91	94
TCM	6th	Male	20.21	10.12	47
		Female	19.65	8.94	39
	Total		19.96	9.23	86
	8th	Male	26.67	9.01	45
		Female	22.27	8.42	49
	Total		24.37	8.73	94

Considering the grade of students, a significant difference (p = 0.013 < 0.05) was found for TL total and TCM (p = 0.021 < 0.05), both with a small-to-moderate effect size measured by eta squared (0.035 and 0.03, respectively). Hence, the 8th graders scored higher than the 6th graders in TL (M = 33.95%, SD = 10.26; M = 30.19%, SD = 9.91, respectively). A significant difference (p = 0.021 < 0.05) was found for the TCM dimension (M = 24.37%, SD = 8.73; 19.96%, 8.94, respectively for the 8th and 6th graders).

Across the sexes, no significant differences (p > 0.05) were found for TL total, TC and TCM, while for TK there was a significant difference (p = 0.036 < 0.05), where the grade 6 females scored higher than males (M = 52.44 %, SD = 14.34; M = 44.68%, SD = 17.76, respectively).

The second objective sought to measure students' attitudes towards technology, classified into six subscales. Figure 1 shows that student perception towards technology is not too positive considering the mid-point of the scale is three. Students seem to be aware of the effects of technology on society and have a positive opinion about the importance of design and technology lessons in the curriculum. Students were still convinced that boys are more capable than girls at technological tasks or jobs. Surprisingly, students perceived the difficulty of technology and engineering does not exceed the mid-point three. Perhaps the term, technology, is not regarded by students as representing complexity in technological fields [1].

Surprisingly, the 6th grade students' attitudes towards interest in technology (IT) seems to be higher than their 8th grade counterparts. This seems to be connected with student motivation and satisfaction with TE, as was recorded in several previous studies [3][10].

Multiple regression analysis with multiple dependent variables was performed using multivariate analysis of covariance (MANCOVA) to see how the independent variables can predict student TL and its dimensions. The results revealed that the combination of the independent variables significantly predicts student TL (F (6,173) = 19.21, (p < 0.001).

Approximately 40% of the variance in student TL was accounted for by the predictor variables. The independent variables significantly predict ($p < 0.05$) all TL dimensions; namely, TK (F (6,173) = 9.44, $p < 0.001$) with 25% explained variance, TC (F (6,173) = 12.19, $p < 0.001$) with 30% of explained variance, and TCM (F (6,173) = 4.48, $p < 0.001$) with 13% of explained variances. The explained variances were calculated using R^2 from the path model where $R^2 = 0.02$ - a small impact, $R^2 = 0.13$ - a medium-effect size, and $R^2 = 0.26$ - a large effect size [10].

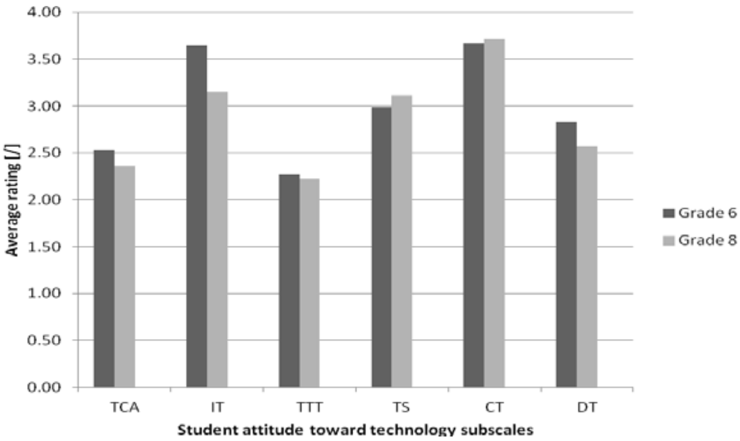

Figure 1: Average ratings for the *Technology and me* subscales (mid-point 3).

Students' attitudes toward technology contributing to TL were investigated. A multiple regression analysis was carried out with the items of students' expectations/perceived importance as independent variables and TL and its dimensions as dependent variables. Beta (β) weights describe the relation between a predictor and a criterion variable after the effects of other predictor variables have been removed. A summary of the multiple regression analyses is shown in Table 3 (n = 180). All reported standardised regression weights are significantly different from zero ($p < 0.01$), where B is the unstandardised coefficient and SE_B is the standard error of B.

Table 3: Multiple regression analysis for TL and its dimensions on students' attitudes towards technology.

Importance of:	Performance in TL and its dimensions:											
	TL			TK			TC			TCM		
	B	SE_B	β	*B*	SE_B	β	*B*	SE_B	β	*B*	SE_B	β
Technology career aspirations	-1.28	0.64	-0.14							-1.92	0.99	-0.16
Interest in technology	2.81	0.77	0.27	4.03	1.47	0.23	4.28	1.21	0.29			
Tediousness of technology	-3.72	0.66	-0.38	-3.16	1.28	-0.19	-4.55	1.04	-0.32	-3.42	1.03	-0.27
Technology and sex differences							1.67	0.74	0.15			
Effects of technology	2.54	0.71	0.24	4.61	1.36	0.25				3.09	1.10	0.22
Technology difficulty	-1.67	0.72	-0.14				-4.48	1.13	-0.27			

Students' attitudes towards careers in technological and engineering jobs significantly ($p < 0.001$) predicts TL and its dimension TCM. As shown in Table 3, students who want to have future careers in technology and engineering education are cognitively not as capable in TL. Interest in technology seems to be an important predictor of TL, TK and TC. These students perceive technology highly positively, but they have no motivation to have a career in technology and engineering. These students have more lessons in design and technology in secondary education, but the majority of these students continue their schooling in general upper secondary school, where there are no technology and engineering subjects. Consequently, engineering faculties at universities lack good and capable students at the outset.

Perceived boredom with technology seems to be a decisive negative predictor of TL and all TL dimensions. It implies that the curriculum designer and technology teacher have a key role. Design and technology subject matter must reflect new technological changes to provide additional motivation for the students; this confirms the findings of Ankiewicz [13].

Belief about male students' superiority on technological/technical tasks that improve their TC ability was not supported. Students advanced in TC, where previous experience with different technologies was helpful at technological problem solving.

Students' perception of the effects of technology was a significant ($p < 0.001$) predictor of TL. These students advanced in TL, TK, and TCM, while problem-solving capacity, TC, was not markedly affected. A perception of the difficulty of technology caused problems at acquiring TL and TC where learning/training is oriented to active learning and hands-on experience.

CONCLUSIONS

Students' attitudes towards technology were found to be an important and significant predictor of technological literacy. Introducing more innovative approaches using different technologies might enhance both interest in design and technology, and technological literacy. Traditional craft-based approaches might provoke negative attitudes towards technology in students, especially their technological problem-solving, critical thinking and decision making. Future research is oriented to how teachers may develop students' behavioural attitudes towards technology.

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