Examining Students' Creativity with the Torrance Creativity Test in Vocational High School

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Abstract— **The rapid development of the industry requires workers to acquire new competences and improve existing ones. One of the main tasks of vocational education and training in the coming years is to develop the competences necessary for employment and occupation. Changes in working conditions are most likely to require the development of creativity. The purpose of this study is to demonstrate what students currently have in creativity and how their development is influenced by vocational training. For the study, the Torrance Creativity Test was completed with a series of questions including professional questions. The research focuses on justifying the presence of hypothesized creativity components and demonstrating whether there is a distinction between professional and general creativity in VET students. The research analyses whether there is a difference in creativity between apprentices and non-vocational students. The main hypothesis is that there is a noticeable difference in the creativity fluency between VET and high school students because VET participants apply their professional knowledge. The hypotheses were tested by analysing the fluency of student responses. The research was carried out among 11th grade students in vocational education and in upper secondary and art education. The 13th grade adults, who are now in vocational training and already have work experience, were also involved. Based on the results of the research, it was confirmed that the supposed creativity components are present. It can be stated that the students' creativity fluency is very poor and they tend to elaborate an idea as much as possible. There is no detectable difference between the 11th grade students and the adults now enrolled in VET, both in terms of general and professional fluency. However, it has not been clearly confirmed whether general and professional creativity can be distinguished.**

I. INTRODUCTION

As a result of the development of industrial technologies, some professions are being terminated, transformed or new ones are being created, with the result that different types of knowledge and, above all, different skills are needed. Employers have been questioned about the 10 competencies employers expect employees to have. In 2015, complex problem solving was the number one priority and is projected to remain the key employee competency by 2020. Creativity was ranked as the 10th most important competency in 2015, but ref. [32] expects it to grow in importance. According to the report, creativity will be ranked third in 2020, ref. [33] says that by 2022, it will be the second (projected first in Australia) most sought-after and needed competency in the labour market [33].

II. THEORETICAL BACKGROUND OF THE RESEARCH - CREATIVITY

A. The concept of creativity

Researchers have tried to interpret creativity in many forms and contexts, so there has been no uniform definition. Some researchers opted for a solution that was not clearly defined, but simply limited [10]. There are different theories for approaching creativity, which can be grouped around each factor of creativity. Several researchers have focused on defining the personality traits that characterize creative people [24] [13] [27] [18]. Other definitions focus on environmental factors, especially those investigating creativity and the potential for the development of SEN students in the school environment [1] [8] [17] [21] [12] [4] [5]. According to some researchers, creativity should be understood as a process [31] [22] [20]. According to the fourth widespread concept, creativity is nothing but unusual thinking [15] [29] [9] with the focus on professional problem solving, the definition of creativity is worth approaching from the psychometric and cognitive lines.

B. Measuring Creativity

The unusual use test developed by Guilford [16] to quantify creativity was the first to measure divergent thinking. The test measured the fluency and originality of the subjects [13]. The only inaccuracy of the test is that the measurement of originality depends on the fluency, since the more answers the test filler gives the higher will be the score given to the originality [19]. Originality is measured more precisely by the Barkóczi - Klein method [3]. The Unusual Usage Test is still used today because of the ease of data acquisition and evaluation, yet it reliably measures. The psychometric approach to measuring creativity has been criticized. Criticism is that creativity measured by tests does not correspond to real creativity, and that divergent thinking is also dependent on the test used [14].

Guilford's test was born almost simultaneously with the Torrance Test of Creative Thinking [25] [26]. The test consists of verbal and non-verbal tasks, which include the unusual use test applied by Guilford, subject optimization suggestions, a question-and-guess question, and a variety of options. The most well-known of the figurative tasks is the circle test, but it also contains a drawing supplement and an image editing task. The Torrance test measures flexibility, fluency, originality, and elaboration. A similar test was carried out by Hungarian researchers in 1965, featuring unusual usage, consistency testing, sentence

completion, and remote association tasks [2] [3]. The task set consisted of verbal tasks only. During the same period, the Wallach - Kogan Creativity Test was completed, which also included only verbal tasks. Such tasks include list of examples, unusual use test, similarity task, and interpretation of pattern and lines [30].

C. Relationship of creativity to problem solving

The development of creativity begins in early childhood, but the rate of development decreases with entry into school. Traditional teaching methods and the school environment do not support the development of creativity. Traditional forms of education focus on criterion-oriented output. Creativity is neither included in the content of VET curricula, nor in the competencies to be developed. So it is an often unrealized educational goal, although those in the construction and surveying sector need to solve life-long professional problems requiring some level of training. - mini c - small c [5] - creativity. Developing creative thinking is the best way for students to be prepared for a dynamically changing work environment [15] [28].

Creativity cannot be sharply separated from other mental-psychic activities and problem-solving. Creativity can also be seen as a tool for complex professional problem solving. Problem solving, in this line of thought, is a creative process that builds on existing professional knowledge and experience, but is the result of rearranging existing knowledge to solve a specific problem. The end result is the development of strategies for solving a given problem, that is, the creative product. The usability and novelty of the end results depends on the individual's level of creativity. The beginner's problem-solving creativity level is expected to be low, on the Beghetto-Kaufmann scale it is at mini c level, so problem-solving management and continuous feedbacks are required. The professional creativity of students entering VET is at this level. The creativity of experienced problem solvers reaches low c, in which case control is replaced by constructive exchange of experience. This is the level students can reach at the end of their professional training. By gaining work experience and expanding experience, the problem solver reaches the Pro c level, which, however, no longer takes place within school settings.

III. PURPOSE OF THE RESEARCH

A. Hypothesis

The present study is aimed at understanding divergent thinking among high school students. Previous research has shown that it takes time for creativity to develop. Some researchers estimate that this period lasts 10 years, when the individual translates that knowledge into practice to become a productive creator over time [6] [14] [11]. However, there is no information about research examining how professional training influences an individual's creative thinking. Whether the individual's creativity is complemented by the fluency, flexibility, or originality of the practitioner's professional knowledge, or does vocational training not affect the individual's creativity. The main question is whether professional creativity exists and, if so, to what extent does it influence the individual's overall creativity.

The aim of the research is to determine whether there is professional creativity in vocational training: professional knowledge pervades creativity even in areas that require solving a general problem independent of the profession. A further aim of the research is to reveal the level of creativity of students currently in sectoral vocational training, to determine if and to what extent the creativity of students is influenced by vocational training during the learning period. Which segment of creativity is the strongest among VET students? In the case of adult learners entering VET, is work experience already influenced by creativity?

The hypotheses of the research:

- Creativity can be divided into distinct components.
- There are detectable relationships between the components of creativity, one component inferring the presence and quality of another.
- Generic and professional creativity can be significantly differentiated.
- There is a noticeable difference in the creativity fluency between apprentices and non-VET learners because VET participants' responses are influenced by the learned profession.
- Vocational training has an impact on creativity, and responses to the learned profession also appear.
- The fluency of problem solving is influenced by the design of a strategy.
- Fluency can be used to identify homogeneous groups of learners.

B. Research Participants

The research was carried out among students in 11th grade vocational and secondary education and 13th grade vocational training in adult education.

TABLE 1
DISTRIBUTION OF STUDENTS IN RESEARCH

Type of group	Grade	Sector	Number of students
study group	11	road construction	13
study group	11	land surveying	11
study group	13	road construction	9
study group	13	railroad construction	17
control group	11	civil engineering	24
control group	11	grammar school	20
control group	11	artistic training	21

In the study groups, subjects were overwhelmingly male, due to the nature of the sectors studied, so it is not relevant to examine the gender gap in creativity. Differences in age have not been analysed either, as the age of adult learners varies widely and 68% of those involved in adult education research are only a few years older than full-time students.

C. Methods used

The participants completed a set of tasks based on the creativity tests developed by Guilford and Torrance. The exercises consisted of verbal and figurative tasks of the following types:

- inventing a strategy - verbal
- Graphic supplementation, pictorial creative thinking - figurative
- Visual similarity - figural-verbal
- Conceptual similarity - verbal
- Problem solving - verbal

Taking into account the above listed types of questions, participants in general and artistic training have been given tasks that include objects, drawings, etc. that occur in everyday life. Vocational training participants were also given further occupation-specific questions. The data collection was conducted in April 2019 for students of vocational secondary schools and in June 2019 for students of high school and arts education. The students completed the tests under standard classroom conditions, so differences due to different classroom climates do not affect the results of the research.

Data were analysed using descriptive and mathematical statistical methods. The correlations were explored by calculating correlation coefficients and by the analysis of variance to detect differences. The correlations and differences can be considered justified with the 95% probability level of pedagogical research. The appearance of the two components of creativity was investigated by cluster analysis.

IV. Results

A. Verification of the components of creativity

In my research, I used several versions of the assignment, depending on whether students in the construction or surveying sectors were in vocational or high school education. Therefore, reliability was examined for each set of tasks, and tasks were measured prior to testing to determine which responses may be related to the particular profession of the learners but are not considered to be effects of the learned profession, given by the students who do not receive vocational training. The reliability of the tests used is confirmed by Cronbach's value, which is presented in Table 2, broken down by test series. It is clear from the reliability metrics that the tests measure reliably.

In the preparation of the tasks, we defined five types of tasks, which were defined in general and professional aspects. When examining the tasks, we also examined the set of tasks, including professional questions, because the participants of the grammar school completed only the part related to general creativity.

TABLE 2
RELIABILITY OF USED TASKS

Type of group	Grade	Sector	Cronbach α
study group	11	road construction	0,800
study group	11	Land surveying	0,769
study group	13	road and railroad construction	0,800
control group	11	civil engineering	0,626
control group	11	grammar school	0,767
control group	11	artistic training	0,814

The hypothesized creativity components were verified by cluster analysis, in which all fluence variables were included. Based on the analysis, strategy-making, visual creative thinking, visual similarity, conceptual and visual similarity, and elaboration of problem-solving ideas can be considered as components of creativity and should be examined separately.

B. Fluency analysis

In the case of fluency, I investigated students' ability to gather ideas for five minutes performing association assignment, strategy development, and problem solving. An integral part of the research is to determine whether the learned or practiced profession has an impact on students' creativity, and how many of the responses to each task can be attributed to the occupant's learned profession. According to this, students' answers can be divided into two groups: general and professional response types.

Descriptive statistics are shown in Table 3. The members of the survey team have the highest fluence; in terms of professional fluency, the rail construction group achieved better results. Grade 11 road builders and 13th grade road builders show similar results, with professional fluency appearing in almost the same proportion of responses. The fluency of 11th-grade students in the construction industry is much lower than expected, especially regarding professional fluency. As this control group, surveyor and road construction study groups have been conducting professional studies for the same amount of time, similar values were expected. The fluency of non-VET students is lower than that of VET students, which can also be explained by the development of the student's creative thinking through VET professional tasks.

TABLE 3
AVERAGE FLUENCY VALUES FOR TESTED GROUPS

Group	All answers	General answers	Professional answers
Land surveying	56,36	45,09	11,27
Road construction	35,09	27,82	7,27
Civil engineering	21,91	19,64	2,27
Road construction	29,87	23,89	6,22
Railroad construction	36,0	23,00	13,00
artistic training	not relevant	4,58	not relevant
Grammar school	not relevant	3,69	not relevant

Vocational education and training students also find professional answers to general questions, but on a very small scale. This means that the students 'creative thinking is already embedded in the students' professional knowledge, but it is not applied automatically unless they are confronted with a question about the profession they are learning. The same considerations apply when looking at the average number of students' responses to a task.

When analysing the components of creativity separately, it can be concluded that each professional training group performed best in conceptual similarity tasks by analysing the answers to all general and professional questions. Non-vocational students achieved the greatest fluency in developing problem-solving ideas. It was the second place for vocational training participants. The fluency of visual similarity is the weakest in both the examined and the control groups, which is quite surprising for the vocational training participants, since the special form of communication of the technical profession is the preparation and interpretation of diagrams and technical drawings.

Because the response rate to professional questions is lower than to general questions, the fluency of the three components of professional creativity is lower than that of average creativity. Fluency values for non-vocational and construction students are nearly the same. Compared to the groups studied, students in the construction sector, in arts and high school, did poorly in general and professional fluency compared to the other groups. Professional fluency is the highest in railway construction (35.65% on average), and the lowest in the construction control group (11.21%). The question is whether statements based on descriptive data can be justified by mathematical statistical procedures, and whether differences between groups can be detected.

In mathematical statistical analysis, there is a close relationship between general and professional fluency at a 99% probability level (r = 0.322). Taking into account all the answers of high school students, there is a close relationship between 99% probability of finding a strategy, visual and conceptual similarity, and problem solving. At the 95% probability level, there is a loose relationship between visual creativity, strategy inventiveness and problem solving. There is neither connection between visual and conceptual similarity nor between visual similarity and visual creativity. Examining general fluency by including the responses of non-vocational students, it can be concluded that only correlation between visual creativity and visual similarity cannot be demonstrated (r = 0.155). When examining purely professional responses, there is only a relationship between problem solving and conceptual similarity at a 99% probability level (r = 0.343). It can also be inferred from this that students usually use analogical thinking instead of creative thinking to solve professional problems. From a professional point of view, there is a negative relationship between inventing a strategy and visual creativity, so the better the learner's elaboration the more difficult it is to develop strategies. Developing the strategy has a 95% probability level of close association with visual similarity (r = 0.257) and problem solving (r = 0.261).

I examined whether homogeneous groups can be formed among students in terms of the fluency of creativity using significantly detectable relationships. Applying the relationships in all combinations and involving all students, although they may distinguish homogeneous groups of students based on their answers to general questions, these groups contain a mixed number of individuals from each of the studied and control groups. The groups thus formed are not the same as the groups of students who have the same profession or grade. I analysed whether homogeneous groups can be created within a student group. In this case, it is possible to form homogeneous study groups within the studied groups by examining the variables of all general questions together. The least homogeneous group is made up of students in the 11th grade construction sector, according to the cluster analysis, the 24 students in the group form 16 groups based on the proximity of their creativity, so this control group cannot be considered homogeneous. This predicts that similar results were obtained when examining the combinations of creativity components. The most homogeneous group consists of 13th grade road building students. In this group only two groups could be formed. Based on these, the surveyor and road construction survey groups can be considered homogeneous, because few groups can be formed in relation to the number of students. Sharp (1991) has already pointed out that engineering is nothing more than problem solving, therefore it is advisable to examine how creativity can be considered as having the same level of creativity on the basis of the components of problem solving, conceptual similarity and strategy development. On the basis of the analysis of the three components, only members of the construction and arts groups cannot be considered homogeneous. Survey students are outstanding: each member of the study group is a group, so the group itself can be considered homogeneous. The 11th grade road construction study group also shows similar homogeneity. Further investigation is needed to prove whether the homogeneity of group creativity in problem-solving and strategy-making can be caused by learning according to the problem-based learning high school model [7]. Based on the cluster analysis of the professional issues (in this case the examination of the students of the grammar school and the arts training is not relevant) the students of the construction industry do not

show a uniform picture here either. Surveyors are less uniform than the fluency of their answers to general questions, but there is much less distance between group members than among students in the construction industry. However, in the case of grade 11 road builders, the homogeneity of the group decreased, with four groups being formed.

When comparing the groups, it should also be examined whether there is a significant difference between them. The assessment was performed by analysis of variance. As a result of the analysis, for all variables belonging to the general question, the value between groups was greater than the value within the group, but on the basis of F test these differences are not considered significant, what means there is no detectable relationship between group creativity fluency. In vocational secondary school students, it is necessary to examine to what extent the answers to the general questions and the answers to the professional questions influence the development of the differences between the groups. In this case too, the value of the variance between the groups is much higher than the value of the intra-group variance for all creativity components, but the F test does not show if there is a significant difference between the examined groups. It was not demonstrated whether there was a detectable difference between general and occupational fluency of students, and only in the 11th grade road construction group could be pointed out that general and occupational fluency are significantly related ($r = 0.746$) at a 99% probability level.

V. SUMMARY

In the research we sought to find out whether there is professional creativity and how vocational training influences students' creativity fluency. This required proof of the supposed problem-solving components of creativity.

In the study of fluency, I came to the same conclusion as ref. [6] and ref. [11]: in the early stages of learning, the learned profession is not yet embedded in everyday creative thinking; it requires at least ten years professional experience to become an inside of the individual. This is also supported by the analysis of variance for all variables and for all students in VET. According to it there is no detectable relationship between the groups. It can be concluded that the students have not yet reached the stage of gaining professional experience, so they still show problem solving features of a beginner.

For all VET groups, based on a contextual analysis, there is a 95% probability that a connection can be found between students' professional problem-solving, conceptual similarity recognition and strategy development. There are more connections between components of 11th grade students' creativity than among adult learners. The question arises whether the creativity of adult learners is below that of 11th grade students.

Although the results presented in the study are limited to the groups studied, important relationships have been found with regard to vocational training, especially in terms of creativity components and problem solving. The descriptive analysis of the data shows that we can speak of professional and general creativity among the students of a profession. Professional creativity has not fully developed during the studies, so the difference between general and professional creativity is not yet apparent in the groups studied. To substantiate this by mathematical statistical methods, it would be necessary to involve groups who have practiced their profession for at least 10 years.

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