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A SOFTWARE INSTRUMENT FOR THE ASSESSMENT OF CREATIVITY IN THE EDUCATIONAL ENVIRONMENT

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Abstract: One of the reasons why we don't have an education system focused on the systematic development of the creativity of the students is that we don't have appropriate instruments for the assessment of creativity in the educational environment. The existing creativity assessment tools reflect the confusion and lack of consensus regarding the nature of the creativity. For the 100 definitions of the creativity there are as many evaluation and measuring tools. Most of them are designed for research purposes, so they are complex, difficult to apply and score, and expensive. The present paper describes the development of a new self report measure for the creativity that can be accessed online, and is easily applicable in the educational environment. To this purpose, we have developed a new scale and a fuzzy logic algorithm for automated scoring. The validation of this instrument is a work in progress, but the initial results are promising

Keywords: Fuzzy inference, Online creativity assessment, e-learning,

1. INTRODUCTION

In the decades following the Guilford call (Guildfor, 1950) for a systematic investigation of the phenomenon of creativity, we witnessed an explosion of the interest for the research on topics related to this domain. The creativity has been explored from various perspectives (Kotzbelt, 2010; Sternber, 1988; Kasof, 1995; Sawyer, 2011), the number of related research articles grows exponentially, and Amazon.com offers over 30,000 books – in English only – with this subject.

Over 100 definitions of the creativity have been proposed (Treffinger, 1996; Aleinikov, 2000), not to mention the related concepts "creative thinking", or "creative problem solving". The explanation of this huge interest for the creativity lies probably on economic grounds. There exists an obvious correlation between the organizational "permeability to innovation", and the market value of the companies (Susnea, 2014c).

According to some estimates (see http://www.oceantomo.com/ocean-tomo-300/) the ratio between intangible assets and total market value of the companies listed in S&P500 evolved from 17% in 1975 to 84% in 2015. These figures are a clear confirmation of the statement formulated by Drucker (1993), who said that the key resource for the economic growth in our modern society is no longer capital or labor, is innovation.

Assuming that *"creativity is the production of novel and useful ideas in any domain"*, and *"innovation is the successful implementation of creative ideas within an organization"* (Amabile, 1996b) it results that systematic education for creativity may be the key for a steady economic growth.

Though there exists a significant body of evidence that creativity can be taught (Pyryt, 1999; Scott, 2004; Birdi, 2005; Osburn, 2006) the School as institution is very slow in adopting specific programs aimed to foster creativity of the students. We discussed elsewhere the multiple reasons for this inertia (Susnea, 2014a; Susnea, 2014b; Susnea, 2014c).

Figure 1 is a graphic overview of the reasons why we don't have a systematic education for creativity.

Among the factors that block the initiatives towards an education for creativity is the lack of assessment instruments compatible with the mass education, i.e. easy to use and free.

The present paper describes a research aimed to fill this gap by developing a web based software self-report measure of the creativity of the students, which allows fast evaluation of their evolution along specific creativity courses. To this purpose, we have designed a new scale with 20 items. This paper describes the new scale, and the algorithm based on fuzzy inference for the automatic interpretation of the user input.

The rest of this paper is structured as follows:

Section 2 is a brief review of the state of the art in what concerns the creativity assessment tools.

Section 3 contains the detailed presentation of the proposed solution.

Finally, Section 4 is reserved for discussion and conclusions.

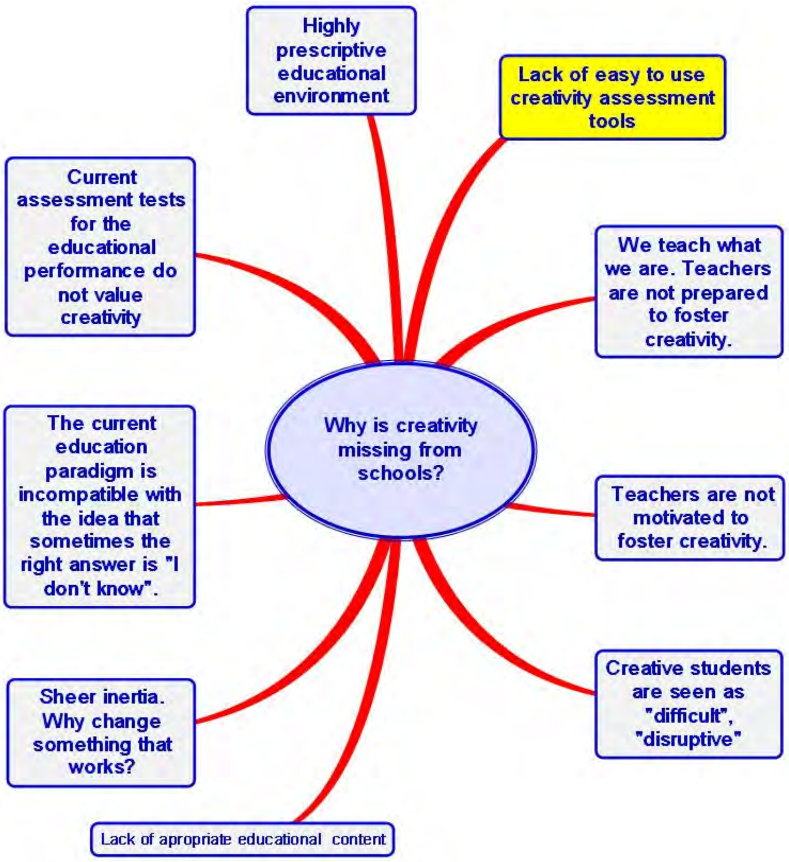

Fig.1. A mind map illustrating the main factors that block the systematic education for creativity

2. LITERATURE REVIEW

Those who believe that the assessment of creativity can be equated to simple tasks like "find as many original uses for a brick as possible" would be surprised to know that this domain has a long history and there exist a wide variety of methods and approaches to measure the creativity.

In fact, the term “creativity” itself seems to designate different realities in various contexts, and it is quite normal that a concept so elusive and hard to define to be equally difficult to measure.

Hocevar & Bachelor in (1989) counted 100 creativity assessment tools and proposed a taxonomy based on the following categories:

- tests of divergent thinking;
- attitude and interest inventories;
- personality inventories;
- biographical inventories;
- ratings by teachers, peers, and supervisors;
- judgments of products;
- eminence;
- self-reported creative activities and achievements

A different taxonomic approach can be found in Kaufman et al. (2008), who describe the following categories of tests:

- divergent thinking
- consensual assessment technique
- assessment by others (teacher, peers, parents)
- self-assessment

And Plucker & Renzulli (2008) propose a taxonomy based on the following dimensions:

- psychometric,
- experimental,
- biographical,
- historiometric,
- biometric.

In this brief review, we will use the approach of Miller (2009), who starts from the definitions of the creativity as manifestations or features of the creative persons, products, processes or places/press (these are the famous 4 Ps of the creativity).

Among the assessment methods focused on the creative person, it is worth to mention KAI - The Kirton Adaptor-Innovator Inventory (Kirton, 1976), SCAB - The Scale for Creative Attributes and Behaviors (Kelly, 2004), and RIBS – Runco Ideation Behavior Scale (Runco, 2001).

The tests focused on the analysis of the creative products are – mostly – divergent thinking tests. In this category is included the most popular creativity test: TTCT – The Torrance Test of Creative Thinking (Torrance, 1974). Despite its popularity, TTCT has been criticized for being cumbersome to apply and score, and its predictive value is questionable (Kim, 2006).

The tests focused on the creative processes are by far less common mainly because the mental processes associated with creativity are little understood. Among these, we cite CPAC – Cognitive Processes Associated with Creativity (Miller, 2014).

Again, the influence of the environment (place/press) on the creativity is difficult to reflect in specific assessment tools, therefore this type of tests is less common. One example is KEYS (Amabile, 1996).

Other tests comprise several subscales, aimed to multiple facets (P’s) of the creativity in the same time. One good example of this type of tests is CSQ-R Creativity Styles Questionnaire – Revised (Kumar, 1997), which contains 78 items, grouped in 7 subscales.

Considering the multitude and diversity of the instruments for the assessment of creativity, one may ask who needs yet another similar tool?

As a matter of fact, all of the existing creativity assessment tools have multiple imperfections and drawbacks. Figure 2 is a graphic overview of these drawbacks.

Fig.2. The main drawbacks of the existing creativity assessment tools

The research described here attempts to address all of these drawbacks by creating a free, easy to use self-report measure, applicable in the educational environment, and with automated scoring.

To this purpose, we created a new scale, and developed a web based software application, which solves the problem of collecting the user’s responses and computes a “creativity quotient” CQ.

3. DESCRIPTION OF THE PROPOSED SOLUTION

3.1. A new scale

Creativity is a notoriously elusive concept, with multiple facets, difficult to describe and define, and even more difficult to measure.

It seems that it is easier to specify what creativity is not, and try to define creativity by means of its “negative space” (see figure 3).

Fig.3. An illustration of the use of “negative space”

So, what is the opposite of the creative thinking? Edward de Bono (1995) answered this question by indicating an equally elusive concept: “the normal thinking”.

What is commonly assumed to be “normal thinking” is in fact the convergent thinking, logical, sequential, associated with the left brain hemisphere. This is not exactly the opposite of the creative thinking, and it is even required in the stage of evaluation and capitalization of the creative products (see figure 4 for an insight into the complex nature of creativity).

Maybe the famous quote attributed to Mark Twain: “*whenever you find yourself on the side of the majority, it is time to pause and reflect”* offers a hint about what is the opposite of creative thinking.

Fig.4. A quick look at the many facets of the creativity

So, we believe that the opposite of creative thinking is not “normal thinking”, but a style of thinking which is superficial, heavily biased by social conformity, stereotypes, prejudices, all kind of learned “rules”, illicit generalizations, and false axioms. The opposite of creative thinking is thinking inside a box of stereotypes and prejudices.

Starting from this idea, we designed a scale with 20 items, organized in two subscales as shown in tables 1 and 2.

Table 1. Subscale for general ideation behavior and creative personality

Item	Statement
1	*An image is worth a thousand words.*
2	*People say I am a bit lazy and scatterbrained.*
3	*I have a great sense of humor, and I always see the funny side of life.*
4	*Sometimes I get obsessed with a problem, and I keep trying until I find a solution.*
5	*A bit of adrenaline is always welcome. Life is boring without it.*
6	*I am very curious.*
7	*People think that I am good at finding solutions to common problems.*
8	*I enjoy trying to find new solutions to problems.*
9	*I have lots of ideas in every domain.*
10	*One plus one does not always equal two*

Table 2. Subscale for stereotypical thinking

Item	Statement
11	*I always play by the rules.*
12	*My parents were very strict with me.*
13	*If anything can go wrong, it will.*
14	*I am very disciplined and diligent*
15	*Sometimes I use oracles when I need to make difficult decisions.* **This item is reverse coded*
16	*I know exactly what I will do next summer.*
17	*I always trust reputable scientists.*
18	*I like to solve the problems one by one.*
19	*I like to quote the opinions of wiser people.*
20	*I feel very embarrassed if I fail.*

Table 3. Additional filler statements

Item	Statement
21	*A journey of a thousand miles begins with a single step.*
22	*I think I have an intelligence quotient (IQ) above the average.*
23	*Whenever you find yourself on the side of the majority, it is time to pause and reflect.*
24	*The path is more important than the destination.*
25	*Make everything as simple as possible, but not simpler.*

The users are prompted to identify, using a 5 point Likert scale, to what extent they agree with the above listed statements.

To avoid attempts to cheat on repeated tests, an additional set of 5 filler statements has been included in the online version of the scale (see Table 3). The user’s input for these items is ignored.

3.2. Automatic interpretation and scoring

Each answer is assigned a numeric value as follows:

- I totally disagree – 0
- I mostly disagree – 1
- I neither agree nor disagree – 2
- I mostly agree – 3
- I definitely agree - 4

Then, the application computes the total score for each subscale:

(1) $$ss_1 = \sum_{i=1}^{10} A_i$$

(2) $$ss_2 = \sum_{i=11}^{20} A_i$$

Obviously, $ss_1, ss_2 \in [0,40]$. Since the two subscales are focused on distinct factors, the final “creativity quotient” CQ cannot be obtained by simply adding or subtracting the scores for the subscales.

One possible way to compute the final CQ is as follows:

(3) $$CQ = 50 * (1 + \tanh(k * (ss1 - ss2))$$

where k is a scaling constant, empirically set to k=0.07.

See figure 5 for the graphic representation of the values of CQ (on the z axis) computed with (3).

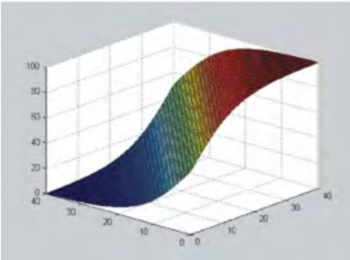

Fig.5. The distribution of the values of CQ computed with (3)

A more elaborate method to compute CQ is by using a fuzzy inference algorithm (Susnea, 2005).

The domain of variation of the variables ss1 and ss2 can be divided in the following fuzzy subdomains (see figure 6):

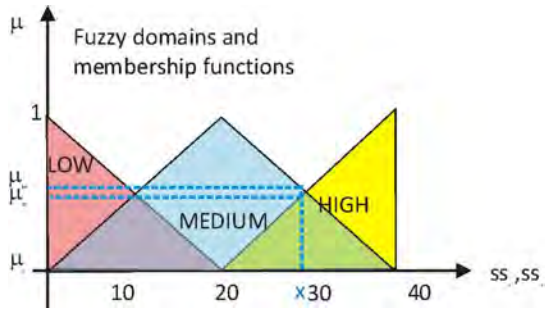

Fig.6. Fuzzy subdomains and membership functions for ss1 and ss2

Assuming that the desired output domain is $CQ \in [0,100]$, we can define the output fuzzy domains as “singletons”, (Si), e.g. $S_{LOW}=10$, $S_{MEDIUM}=50$, and $S_{HIGH}=100$.

With these notations, the input-output dependency can be described using a set of “rules” of the following type:

IF (ss1 is LOW) AND (ss2 is LOW) THEN CQ is LOW

The whole rule base is shown in table 4.

Table 4 The fuzzy rule base used to compute CQ

ss1	ss2	CQ
LOW	LOW	LOW
LOW	MEDIUM	LOW
LOW	HIGH	LOW
MEDIUM	LOW	MEDIUM
MEDIUM	MEDIUM	MEDIUM
MEDIUM	HIGH	LOW
HIGH	LOW	HIGH
HIGH	MEDIUM	HIGH
HIGH	HIGH	MEDIUM

The fuzzy truth values μ_L, μ_M, μ_H of the statements (ss1 is LOW), (ss1 is MEDIUM), (ss1 is HIGH), (ss2 is LOW), (ss2 is MEDIUM), (ss2 is HIGH), for specific values of ss1, ss2 are computed starting from the equations of the membership functions.

And the final truth value of the statement associated with the rule i $IF(\mu_1)\ AND(\mu_2)$ is:

(4) $$Zi = \min(\mu_1, \mu_2)$$

The resulting final value of CQ is:

(5) $$CQ = \frac{\sum_{i=1}^{i=9} Zi * Si}{\sum_{i=1}^{9} Zi}$$

For details regarding the fuzzy inference see for example ([30]).

A beta version of the web application can be tested at http://dev.ugal.ro/creativity/. Obviously, the software application contains additional modules for general administration (e.g. user authentication, database management for the results of the tests) and report generation.

4. DISCUSSION AND CONCLUSIONS

As Miller stated in (2009): “It should be noted that the validation of any instrument is an ongoing procedure.... Once a measure has been adequately developed, it is the responsibility of all researchers in the field to further the generation of evidence for its validity.”

So far, we have only conducted simple pretest for internal consistency with N=30 undergraduate students of the Faculty of Automation, Computers, Electrical and Electronics Engineering of the University “Dunarea de Jos” of Galati. This resulted in $\alpha = 0.73$ for subscale 1, and $\alpha = 0.78$ for subscale 2.

Further validation work is obviously needed. Due to lack of funding, our work in this direction is much slower than we hoped.

However, the initial results are promising: the proposed assessment instrument is free, easy to use, can be used for self-assessment in the educational environment, and – last but not least – can be easily integrated in almost any e-learning platform.

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