

## The IPOO-model of creative learning and the students' information processing characteristics

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**Abstract:** The present study was designed to examine secondary school students' information processing characteristics during learning and their relationship with the students' academic averages, internal motivation for learning and cognitive abilities, such as intelligence and creativity. Although many studies have previously focused on this issue, we are now studying this topic from the perspective of the IPOO-model, which is a new theoretical approach to school learning (note: IPOO is an acronym of Input, Process, Output, Organizing). This study featured 815 participants (secondary school students) who completed the following tests and questionnaires: Raven's Advanced Progressive Matrices (APM) intelligence test, the 'Unusual Uses' creativity test (UUT), the 2<sup>nd</sup> version of the Jupiterbolha-próba (Jupiter Flea test - JB2) to test the information processing method of learning, and the Learning Attitude Questionnaire (LAQ). In our analysis we took the gender, school grade and academic average of participants into account. According to our results, the quality of information-processing methods of learning is at a low level, and there are no significant strong correlational relationships among the tests and questionnaire results (except in the cases of fluency, originality, and flexibility). There were no significant differences between genders or classes. These findings are consistent with the findings of previous studies.

**Keywords:** information processing, creativity, learning, IPOO-model, secondary school students

## IPOO-model ustvarjalnega učenja in značilnosti procesiranja informacij pri učencih

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**Povzetek:** Namen raziskave je bil preveriti, kako učenci v srednji šoli procesirajo informacije med učenjem in kakšen je odnos med značilnostmi procesiranja in njihovo učno uspešnostjo, notranjo motivacijo in kognitivnimi sposobnostmi, kot sta inteligentnost in ustvarjalnost. Čeprav so bile na tem področju v preteklosti že opravljene raziskave, se pričujoča študija te problematike loteva z vidika IPOO-modela, ki predstavlja nov teoretski pristop k šolskemu učenju (IPOO je akronim za *Input* (vnos), *Process* (proces), *Output* (izdelek), *Organizing* (organizacija)). V raziskavi je sodelovalo 815 dijakov, ki so izpolnili naslednje teste oziroma vprašalnike: Ravenove zahtevne matrice (APM), Test ustvarjalnosti »Nenavadne uporabe« (UUT), Jupiterbolha-próba test – druga verzija (JB2) za testiranje učne metode procesiranja informacij in Vprašalnik učnih stališč (LAQ). V raziskavo smo kot spremenljivke vključili tudi spol, razred in povprečno učno uspešnost sodelujočih učencev. Rezultati so pokazali nizek nivo kakovosti učne metode procesiranja informacij in nepovezanost med testnimi rezultati ter rezultati na vprašalnikih (razen v primeru fluentnosti, originalnosti in fleksibilnosti). Razlike med spoloma in razredi se niso izkazale kot statistično značilne. Ugotovitve so skladne z ugotovitvami predhodnih študij.

**Ključne besede:** procesiranje informacij, ustvarjalnost, učenje, IPOO model, dijaki

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In the studies and theories which focus on the information processing related to creativity (for example early works of Cropley, 1997; Davis, 1992; Helmholtz, 1986; Kris, 1953; Stein, 1974; Wallas, 1926; Whiting, 1958; and others), we can find descriptions of a kind of neutral, general creative thinking which exists without specifically defined creative areas (e.g. cooking, painting, writing etc.). These theories and descriptions are generally sufficient, and are applicable in numerous situations; however, we must recognise that more specific models of creative process may be needed in different areas of culture and/or talent. One such area is school learning. However, creative learning is distinct from general creativity (which can be characterized by fluency, originality and flexibility), because of its focus on the creative information processing procedure involved in learning itself (Craft, Cremin, Burnard, & Chappell, 2007; Jeffrey, 2006).

On the other hand, there are different models of school learning (for example Bloom, 1968; Bruner, 1961; Carroll, 1963; Galperin, 1989), but these models do not concentrate sufficiently on creative learning. In addition, neutral, general creativity is a frequent, but not central variable in studies of school learning (Cropley, 2003). In these studies general creativity is only one variable of the other background factors (for example intelligence, motivation, gender, age or school grades) of learning.

In this article we study learning from the perspective of the IPOO-model, which is a new theoretical approach to creative school learning (Mező, 2011).

## The IPOO-model of Learning

According to the IPOO-model (built on a cognitive psychology basis), school learning is an information processing procedure, and has four components: input, process, output and organizing (Mező, 2011). Every component is built on the basis of special abilities, motivations, and methods.

Learning problems can be found in every component of the IPOO-model. For example some typical learning problems of the input phase are “What will the topic of learning be?”, or “Where can I find information about my learning topic?”, or “How can I use the authorities (authoritative sources) effectively?”. Learning problems can occur in the process phase of learning – e.g. “I don’t understand the text, or the lesson!” or “I have to learn too much. I cannot memorize everything...” Subsequently, learning problems can be encountered in the output phase, for example, “I hate oral exams.”, “How can I write my dissertation?”, or “How can I apply my knowledge in my life?” Last, but not least, organising-problems can include the classical problems of the time, the place and the cost of learning etc.

In this learning model, we can differentiate three information-processing possibilities based on the relationship between input and output: the information-processing method of learning may be reproductive, productive, or cause information loss (Table 1).

The main indication of deficient learning is that quantitative and qualitative characteristics feature less in the output (e.g. in an oral exam) than in the input (e.g. in a book), i.e. input > output. If the input is greater than the output, the learning will be ineffective. For example, a poem has four stanzas (as input), but the learner can reproduce (as output) less than four verses. The most important characteristic of learning of this kind is information deficit.

In the case of reproductive learning, the input is same as the output (input = output). If the input is equal to the output, the learning will be reproductive without any creative information processing. For example, a poem has four stanzas (as input), and the learner can recite (as output) all of the four stanzas, but she/he does not understand the words, the stanzas, the poem, or the metaphors within the poem, etc. The learner tries to memorise the lesson word by word without the need for understanding, or basic processing.

Finally, productive learning can be described by the following inequality: input < output. If the input is less than the output, learning will be meaningful, holistic and creative. For example, a poem has four stanzas (as input), and the learner (at the moments of output) can recite all of the four stanzas and she/he understands the poem, and she/he searches for the nexus between the new lesson and his/her earlier knowledge.

In the case of the IPOO-model, the learning ideal is creative, productive learning. If students’ learning styles cause information loss or are reproductive, then learning development is needed (e.g. our applied learning developmental program is the “IPOO-minimum program”).

## Background Factors of Learning

The intrapersonal factors of learning have been studied for several decades. The most frequently identified factors of these studies include intelligence, creativity, and motivation. Researchers often use these factors to predict the learning achievement which is generally operationalized as an academic average. We provide a brief overview of these factors in the following section.

The role of intelligence in learning achievement has been a central question since the dawn of intelligence testing (consider, for example, the creation of Binet’s intelligence test). According to a number of studies (e.g. Neisser et al., 1996; Sternberg & Grigorenko, 2007), there is a relationship between IQ scores and school achievement (the value of the correlation is about  $r = .50$ ). Researchers have long disagreed about the existence of gender differences in overall intelligence (Petersen & Hyde, 2010). While we can find studies which have reported gender differences (e.g. Furnham, Clark, & Bailey, 1999; Hyde, 2005; Lynn, Irwing & Cammock, 2002), other studies find no gender differences in intelligence (e.g. Brody, 1992; Halpern & LaMay, 2000; Jensen, 1998).

Researchers have been studying the relationship between creativity and learning since the fifties of

Table 1. *Examples of different processing approaches to an input (e.g. a school subject) text, and their possible outputs (the interpretative frame is the IPOO-model of learning)*

INPUT: <i>Let us imagine that the text of a school subject...</i>	→ PROCESS by:	→ OUTPUT: <i>In the case of an oral/written exam, we can observe that the learner communicates...</i>
	Productive (creative): re-editing	...a creative product: a non-confused text
...is a confused text (from the perspective of a learner or anybody else)	Reproductive: mechanical memorising of the input without re-editing (but re-editing is possible in the future)	...a confused text (identical to the input text)
	Information loss: not enough memorisation of the input text, making it impossible to re-edit it in the future (without re-learning, of course)	...nothing, or a more confused text than the original input text
...is a mix of essential and non-essential explicit information	Productive (creative): highlighting essential information and rejecting non-essential information	...a creative product: highlighting the essence
	Reproductive: mechanical memorisation of the input (without highlighting essentials - but highlighting is possible in the future)	...a text identical to the input
	Information loss: not enough memorisation of essential and non-essential information of the input text so it is impossible to recall this in the future	...a text with less explicit information than the input
...contains implicit information	Productive (creative): creating explicit conclusions	...creative products: explicit conclusions based on the text
	Reproductive: mechanical memorisation of the input (without creating explicit conclusions - but this is possible in the future)	...a text identical to the input (without explicit conclusions)
	Information loss: not enough memorisation of the input text, making it impossible to find explicit conclusions in the future	...a text that contains less implicit information than the input
...contains atomistic information in different paragraphs and/or chapters	Productive (creative): finding relationships among different paragraphs, texts and prior learning	...a creative product: holistic knowledge
	Reproductive: mechanical memorising of the input (without looking for relations among pieces of information – but this is possible in the future)	...a text that is a set of atomistic pieces of information
	Information loss: not enough memorisation of the atomistic information of the input text so it is impossible to find relationships among non-memorised pieces of information in the future	...a text that is an incomplete set of atomistic pieces of information from the input text

the 20th century, when Joy Paul Guilford proposed the “Structure of Intelligence” model of human intelligence (Guilford, 1950, 1962). According to Guilford, creativity is important from a learning perspective, but it is kept in the background during school learning. Later studies have not been able to refute this (Feist & Runco, 1993; Lucas, 2001; Runco, 2007; Sternberg & Lubart, 1999). The correlation between creativity and academic achievement is usually  $r \leq .30$  (Cromptley, 2003). Baer (2012) reviewed more than 80 studies related to gender differences in creativity and concluded that the results of these studies

are quite contradictory and the evidence does not clearly support gender differences.

In terms of learning motivation, according to Józsa (2000), the relationship between school achievement and learning motivation changes during the school years, with the two becoming more and more independent of each other as the years pass. According to Gordon and Austin (2002), “...the examinations of gender and achievement differences in motivation have histories that span at least three decades” (p. 293). As in the case of most psychological variables with a history stretching back

several decades, the results are sometimes contradictory in the area of learning motivation, too. One of the few areas of consensus on this topic is that, in an ideal case, students have internal motivations for learning (Ryan & Deci, 2000; Sullo, 2007).

As we have seen, research of the intrapersonal background factors of learning has a tradition stretching back several decades. A number of researchers have focused on the predictive roles and correlations of cognitive abilities (e.g. intelligence and creativity) and non-cognitive factors (e.g. motivation) from the perspective of school achievement (e.g. academic average). Although these are classical and traditional variables of learning research, from time to time it is necessary to study these variables from the perspective of new learning theories (for example the IPOO-model of learning). Therefore, the aim of our study was to gain insight into secondary school students' characteristics in terms of information processing during (creative, productive) learning, and to analyse the relationships between these characteristics and cognitive abilities, internal motivation, and academic average. According to our classroom observations, these factors are fairly independent from each other, so we cannot use them as predictors of each other. We also addressed the issue of gender equality.

## Method

### Participants

Participants were 9<sup>th</sup> to 12<sup>th</sup> grade students with a mean age of 16.01 years ( $SD = .97$ ), attending two middle secondary schools in Hungary. The total number of participants was 815. The sample was gender heterogeneous; about 25% of students ( $n = 202$ ) were male. Two hundred and thirty-eight students were 9<sup>th</sup> graders ( $M_{age} = 14.96$ ;  $SD = .42$ ), 261 were 10<sup>th</sup> graders ( $M_{age} = 16.08$ ;  $SD = .65$ ), 218 students were 11<sup>th</sup> graders ( $M_{age} = 16.91$ ;  $SD = .38$ ), and 98 students were 12<sup>th</sup> graders ( $M_{age} = 17.60$ ;  $SD = .52$ ). Although this is an ad hoc sample, which is not representative enough, we think that this study can provide sufficient preliminary results for further examinations.

### Instruments

Creative learning was measured with the Hungarian version of the JB2 test (the Jupiterbolha-próba or, in English, the "Jupiter Flea" test; Mező, 2011). Its subscales refer to re-editing ("Do students create a new and systematically logical structure when they encounter a confused text?"), direct info-management ("Do students find the direct essential information in a text?"), indirect info-management ("Do students create conclusions?"), and holistic learning ("Do students look for relationships with their knowledge?"). The total score is the average of these subscales. For the purpose of this study, we used

mainly the "total score" variable of this test to measure creative learning. The reliability of the total score of the JB2 was  $\alpha = .78 - .87$  (Mező, 2011).

We used Raven's Advanced Progressive Matrices test (APM; Raven, Raven & Court, 1998) for measuring general intelligence – for more information about the Hungarian adaptation of Raven's APM, see Rózsa (2006) and Mező and Kurucz (2014). Some researchers believe that scores on the Raven's Progressive Matrices test give the best estimate of general intelligence (the "g factor"; see Jensen, 1998; McLaurin, Jenkins, Farrar & Rumore, 1973). The APM has two different parts: APM-I (with 12 items) and APM-II (containing an extra 36 items for those who are good at APM-I). The total APM score is the sum of these parts. APM reliability is  $\alpha = .85$ .

Fluency, originality and flexibility (as classical creativity variables) were tested by applying the Unusual Uses Test (a subtest of the Torrance Tests of Creative Thinking, TTCT; Torrance, 1966), based on Guilford's Alternative Uses Task (Guilford, 1962). In this task subjects are asked to list as many uses as possible for a common household item (such as a brick, a pencil or a key). This task is the "Unusual Uses" subtest of the TTCT and it is used to measure such components of creative thinking as fluency (the sum of relevant answers), originality (the infrequency of responses), flexibility (differences in the categories of the responses), average originality (originality/fluency), and relative flexibility (flexibility/fluency). Barkóczi and Zétényi (1981) provide information about the adaptation of the "Unusual Uses" test for the Hungarian population. The  $\alpha$  value of these tests ranges between .70 and .90 (Cropley, 2003).

Internal learning motivation was assessed by applying the Learning Attitude Questionnaire (LAQ; Kontra, 2006) which consists of 31 items with a five-point response scale (1 = it is non typical of me; 5 = it is typical of me). There are six subscales: further education ambitions, interest, predisposition to industrious learning, learning for a good rating, learning for a good position among peers, and learning for rewards. We used an "internal learning motivation" variable based on the mean of the first three subscales (the Cronbach  $\alpha$  is .81; Kontra, 2006).

Our control variables were gender (male/female) and grades (grade 9<sup>th</sup>, 10<sup>th</sup>, 11<sup>th</sup>, and 12<sup>th</sup>).

### Procedure

Participation was not obligatory in this study. The students and their parents were informed about the subject of the study before testing and they were able to make a decision about whether to participate or not. Consequently, our subjects had some kind of internal motivation to participate in this examination, so we did not need to use external motivators (e.g. money, good marks etc.) in order to involve participants.

We met our participants on four different occasions during this examination. In the first session, we tested creative thinking by applying the Unusual Uses Test and

Table 2. Descriptive statistics and tests of normality of the examined variables

Scales <sup>a</sup>	Min	Max	Mdn	M	SD	Skewness <sup>b</sup>	Kurtosis <sup>b</sup>	Kolmogorov–Smirnov Z
Academic average	2.10	5.00	3.90	3.86	0.57	–0.24	–0.52	1.54*
JB2: Re-editing	0.00	100.00	25.00	29.74	24.34	0.66	–0.22	4.62*
JB2: Direct info-management	0.00	100.00	62.50	56.58	20.82	–0.34	–0.44	4.29*
JB2: Indirect info-management	0.00	100.00	50.00	45.57	21.74	0.09	–0.32	3.27*
JB2: Holistic learning	0.00	100.00	25.00	30.77	21.03	0.21	–0.73	3.56*
JB2: Total Score	3.13	93.75	40.62	40.66	16.16	0.22	–0.29	1.75*
APM: Total Score	11.00	47.00	31.00	30.36	5.39	–0.59	0.45	2.59*
LAQ: Internal motivation	1.80	4.60	3.40	3.37	0.49	–0.27	0.08	1.90*
UUT: Fluency	1.00	48.00	9.00	10.08	5.29	1.14	3.58	2.64*
UUT: Originality	0.37	29.00	5.27	5.80	3.49	1.54	4.82	2.36*
UUT: Flexibility	0.00	19.00	8.00	7.81	3.53	0.40	–0.08	2.23*
UUT: Average originality	0.17	3.00	0.53	0.59	0.26	3.60	19.43	6.44*
UUT: Relative flexibility	0.00	12.00	0.83	0.83	0.43	20.95	535.67	9.51*

<sup>a</sup> JB2: Jupiter Flea test, APM: Advanced Progressive Matrices test, LAQ: Learning Attitude Questionnaire, UUT: Unusual Uses test

<sup>b</sup>  $SE_{\text{Skewness}} = .09$ ;  $SE_{\text{Kurtosis}} = .17$

\*  $p < .05$

we also applied the Learning Attitude Questionnaire. On the second occasion participants filled in the APM test. The JB2 was applied during the third session. At the final session, we discussed the results with the participants. Every session lasted around 45 minutes, and was held at their school.

## Results

According to the Kolmogorov-Smirnov test (Table 2), the distributions of researched variables were not normal ( $p < .05$  in all cases). However, the values of skewness and kurtosis are near zero in several cases (the absolute value of the difference from zero is less than 1 for skewness and

this difference is less than 3 for kurtosis), so we could use parametric tests for these variables. However, the skewness and kurtosis of about half of our variables are higher, therefore we consistently used non-parametric statistical tests.

Table 2 shows that the mean values of JB2 variables and information-processing achievements are at fairly low levels. The results of about 75% of the participants are less than 50% in re-editing and holistic learning. Approximately 50% of participants scored less than 50% in the case of indirect info-management. It seems that direct info-management was the easiest task of the JB2 because a significant proportion of participants achieved a result above 50%. Overall, the JB2 total score was less than 50% in most cases.

Table 3. Mean ranks and the results of the Kruskal Wallis test for testing the differences on the used variables between the school grades

Variables	Mean rank of grade				$\chi^2$ (df = 3)
	9 <sup>th</sup>	10 <sup>th</sup>	11 <sup>th</sup>	12 <sup>th</sup>	
Academic average	401.79	376.49	441.19	433.17	10.33*
Re-editing	372.30	381.68	452.28	466.29	23.10*
Direct info-management	355.37	392.79	441.18	502.53	34.21*
Indirect info-management	382.58	393.69	417.88	485.84	15.28*
Holistic learning	352.07	432.98	422.64	444.74	20.19*
Total Score	348.25	396.87	444.39	501.80	36.80*
APM	362.18	428.18	433.58	408.64	13.56*
Internal motivation	417.25	407.54	402.71	398.51	0.64
Fluency	400.03	374.35	442.27	440.74	12.17*
Originality	411.89	413.88	402.19	395.81	0.62
Flexibility	406.26	363.30	442.75	453.96	18.04*
Average originality	426.92	458.73	360.06	328.94	33.79*
Relative flexibility	419.09	392.00	410.69	417.69	1.97

\*  $p < .05$



Table 4. Spearman's rho correlations between all examined variables

Variables <sup>a</sup>	Academic average	JB2: Re-editing	JB2: Direct info-management	JB2: Indirect info-management	JB2: Holistic learning	JB2: Total score	APM: Total score	LAQ: Internal motivation	UUT: Fluency	UUT: Originality	UUT: Flexibility	UUT: Average originality
JB2: Re-editing	.05											
JB2: Direct info-management	.13*	.28*										
JB2: Indirect info-management	.16*	.35*	.49*									
JB2: Holistic learning	.11*	.46*	.34*	.34*								
JB2: Total score	.13*	.72*	.71*	.73*	.72*							
APM: Total score	.49*	.18*	.17*	.23*	.23*	.27*						
LAQ: Internal motivation	.01	-.02	-.01	-.01	-.01	-.03	.00					
UUT: Fluency	.07	.03	.04	.10*	.06	.08*	-.03	.00				
UUT: Originality	.04	.04	.00	.08*	.03	.05	-.01	.01	.84*			
UUT: Flexibility	.07*	.08*	.08*	.08*	.09*	.11*	-.02	-.01	.90*	.74*		
UUT: Average originality	-.02	.05	-.02	-.03	-.01	.00	.04	.08*	-.09*	.37*	-.08*	
UUT: Relative flexibility	-.04	.07	.07*	-.07	.03	.04	.07*	-.02	-.48*	-.49*	-.11*	.02

<sup>a</sup> JB2: Jupiter Flea test, APM: Advanced Progressive Matrices test, LAQ: Learning Attitude Questionnaire, UUT: Unusual Uses test

According to the results of the Mann-Whitney U test, there are significant differences between males and females in terms of direct and indirect information management ( $U = 49827.50$  and  $56304.00$ ; in both cases  $p < .05$ ). Females' results (*mean rank* = 417.15 and 427.72) were better in these areas than males' results (*mean rank* = 348.17 and 380.23). It should be noted that the females' academic averages were also better ( $U = 53786.50$ ;  $p < .05$ ; *mean rank* of male = 367.77; *mean rank* of female = 421.26) but we did not find significant differences between genders in terms of intelligence (this finding confirms the results of Brody, 1992; Halpern & LaMay, 2000; Jensen, 1998). Besides, the Kruskal Wallis test showed significant differences among grades in the following variables (Table 3):

- participants from higher grades generally had better results on the APM and all the JB2 variables;

- participants from 10<sup>th</sup> grades had lower results in academic average, fluency and flexibility;
- in terms of average originality, the 9<sup>th</sup> and 10<sup>th</sup> grades students had better results than their 11<sup>th</sup> and 12<sup>th</sup> grade peers.

Table 4 shows the Spearman's correlations among the variables; there are only two high correlations, i.e. between fluency and originality ( $r = .84$ ) and fluency and flexibility ( $r = .90$ ). A moderate correlation is found between originality and flexibility ( $r = .74$ ) and between the total score and the subscales of the JB2 test ( $r = .71 - .73$ ). We can see slightly weaker relations between intelligence and academic average ( $r = .49$ ), originality and relative flexibility ( $r = -.49$ ), fluency and relative flexibility ( $r = -.48$ ), originality and average originality ( $r = .37$ ). In the cases of other significant correlations,  $r$ -values are less than .30.

## Discussion

According to our results, a significant proportion of students do not use spontaneously productive (creative) information-processing methods for learning. If they meet a confused (or maybe over-long) text, they do not re-edit the text, they do not look for the direct (explicit essential facts) and indirect (implicit but deducible) information, and they do not seek the cross-relations among the subjects, books, chapters or paragraphs. This is a problem in two senses. Firstly, their school learning would be more effective in terms of understanding, timing etc., if they used productive learning methods. Secondly, their poorer information processing strategy could cause disadvantages during their adult life, in the labour market, and in business life and family life.

The test results indicate that predicting the academic average is practically impossible, either from the results of creativity tests or from students' knowledge of information-processing approaches to creative learning or internal motivation. Behind these facts, it is assumed that the teachers are inconsistent when they evaluate the learners' school achievements, and they do not differentiate among students based on motivational dispositions such as learning attitude. It is probable that they often require reproductive learning for good marks, and they sometimes do not require productive (creative) learners. This hypothesis can be tested by observation and content analysis of real exam situations.

The correlation between intelligence and academic average was  $r = .49$ , and this is similar to previous findings (see Neisser et al., 1996). However, the correlations show that higher intelligence is not necessarily associated with more productive information processing during learning, something which also corresponds with other researchers' results (Balogh, 2004). This also means that the development of creative (productive) learning and thinking may be a necessary component of talent development programs in the area of intellectual talent, too (Mező, 2011). Given that intelligence does not correlate with internal learning motivation, motivation-oriented programs may be also central elements of talent development programs for children of high intellectual ability.

In this study we have observed that although the creativity variables of the Unusual Uses Test correlate strongly with each other (confirming the results of Cropley, 2003), these barely correlate with variables of creative information-processing (measured by the JB2 test). This is explained by the fact that the Unusual Uses test and the JB2 test focused on other aspects of the creative process and products. The Unusual Uses test is directed at the number and variety of novel ideas (as a kind of creative product); these kinds of ideas can give information about a type of creative thinking (such as information processing). In contrast, the number, variety and novelty of ideas are less important for the JB2 test, although when dealing with a confused text it is important

to create a new logical structure which contains essential information and conclusions, and holistic relationships. It seems that this approach is more lifelike and occurs more frequently during school learning than the "fluency", "flexibility" and "originality" orientated approaches of the Unusual Uses test. The result also shows that the role of classic creative abilities (e.g. fluency, originality and flexibility) is limited during school learning and teaching – this has been well known since the 1950s (e.g., Guilford, 1962). However, it should be noted that these creative abilities might play an important role in the case of out-of-school learning, autodidact learning, and in the school itself (when students do not learn, but create knowledge during an oral/written exam).

Finally, we should note that we did not find gender differences in the case of intelligence or creativity, but we found that females have better academic averages and information management.

## Limitations

A potential drawback concerns the rather specific sample, which was not randomly selected from the full range of possible secondary school students. Another problem is that the gender ratio is not balanced (male students are under-represented in this sample) and does not mirror the boys to girls ratio in the schools. At the same time, we are convinced that our sample was sufficiently heterogeneous and our other data (from observations in schools in exam situations and interviews with teachers – these are currently being processed) confirm the results of this study.

Another limitation of this study is that just one test was used to measure the information-processing characteristics of learning (creative learning), and that this test was verbal, similar to the creativity test, which restricts the generalizability of the results.

## Future Research and Implications for Practice

The future development of the JB2 will aim to improve its psychometric characteristics, and also to make it shorter. It would be important to examine information processing characteristics during (creative) learning across different age groups and cultures.

The practical implications refer to the need for more learning development programs, which focus on productive learning methods (nowadays we know of only one learning development program, which fits this purpose: the IPOO-creative learning program). On the other hand, it is important that this program becomes a fundamental component and part of teacher training. In order to achieve this aim, we need to develop better learning-diagnostic instruments, methods, protocols and teacher training programs than our presently available instruments and methods.

## Conclusions

The observable creative information-processing characteristics of secondary school students' learning are of disappointingly poor quality (independently of their cognitive abilities, learning motivation etc.). From a retrospective viewpoint, we should explore these factors (e.g. the role of education, the curriculum, teaching materials, teachers' evaluation practice etc.) which induce these results. On the other hand, from a prospective viewpoint, we should develop and teach those methods of teaching and learning which can increase the quality of the creative information-processing aspect of learning.

Our results have shown that cognitive abilities, the internal motivation for learning, the academic average and the information processing style of learning are, taken individually, fairly unreliable in terms of their use in making predictions about other factors. One practical consequence of these results is that we have to handle these learning variables separately when we want to test and/or develop them.

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