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Relationship between the Visual-Spatial Ability and Achievement on PISA Reading Literacy

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Abstract: The assumption that the educational needs of students with a higher visual-spatial ability can be met by including non-continuous texts in the educational practice was empirically tested on a convenience sample, comprising 191 14-year-olds from three Belgrade elementary schools. The findings, obtained after applying ANOVA and ANCOVA, attested to a linear relationship between the measure of visual-spatial ability and PISA unit achievement, both with continuous and non-continuous text formats. The differences between these findings and those of previous study, upon which this work is based, were interpreted in light of the possibility that relative strength in the visual-spatial domain, compared to verbal ability, could be associated with the way the unit is approached, rather than with achievement. The confirmation of this assumption could speak in favor of respecting students' different cognitive styles.

Keywords: visual-spatial ability, OECD/PISA, reading literacy

When deliberating reading, the question arises of the relationship between the reading skill in the general population and reading disability with which part of the population is faced. Keith Stanovich (1988, 1999) provided an empirically grounded answer to this question. By postulating a unique cause of the appearance of different forms of reading disability, this author established a mutual relationship between the reading disability and reading skill, as well as between different forms of reading disability. This view has

implications both for the process of identifying and for the actions of adjusting the educational process to the students' needs (Stanovich, 1999). Furthermore, seeing the reading skill at a multidimensional continuum, with dyslexia as its left end (Stanovich, 1988, 1999), provides a broader frame for finding an empirically grounded way to provide educational support to students who exhibit reading disability. This view has thus been adopted in an attempt to understand better the relationship between the reading skill and visual-spatial ability (Mutavdžin, 2015) in order to provide teachers with empirically founded guidelines for classroom work.

Is reading disability related to strength in the visual-spatial domain?

When researching indications of the connection between the strength in the visual-spatial domain and reading disability, continuous empirical and theoretical efforts of Ellen Winner and Catya von Károlyi stand out (von Károlyi & Winner, 2004). Still, despite the given continuity in research, the authors determined only one aspect of the impossible figures task where people diagnosed with dyslexia have an advantage—the speed of identifying figures "that could not exist in three-dimensional space" (von Károlyi & Winner, 2004, p. 114; von Károlyi, 2001). The said findings were soon replicated (von Károlyi, Winner, Gray, & Sherman, 2003). In other tasks and tests, as well as in terms of the accuracy of identifying impossible figures, no difference was found between the achievements of the group comprising students diagnosed with dyslexia and the group of students without this diagnosis, or there was a difference in favor of the latter group (von Károlyi, 2001; von Károlyi et al., 2003; Winner et al., 2001).

Contrary to the described research, as previosly mentioned, a study conducted in Serbia (Mutavdžin, 2015) adopted Stanovich's (1988, 1999) view, and the reading skill was treated as a continuum. In this way, on a convenience sample of 128 students enrolled in the higher grades of elementary schools in Belgrade, I uncovered indications that there is a nonlinear relationship between visual-spatial ability and continuous text reading skill. Findings obtained by observing the relationship between the visual-spatial ability and reading speed, after controlling for the effect of general cognitive ability, attract attention. Namely, participants with below-average achievements on the visual-spatial ability test read faster than the participants who had the highest achievement on that test. The difference was close to the value of one standard deviation.

Relevance of visual-spatial ability for school achievement

Given the abovementioned, the question arises how to support those students who, along with strong visual-spatial ability, exhibit difficulties when dealing with continuous text. General recommendation is to rely on an individual's strengths (Betts & Neihart, 1988), but David Lohman pointed out the complexity of the answer to the posed question. This author (Lohman, 2005) stated that success in the school context is mostly based on the abilities of verbal and quantitative reasoning, while "the skills that are specific to the figural test are only rarely required in formal schooling" (p. 116). Lohman (2005) used empirical data to corroborate this stance as well as the conclusion that isolated, relative strength in spatial ability can be an inaptitude for some aspects of school learning (p. 122).

David Lubinski (2010) highlighted the possibility that a curriculum with a multitude of abstract, verbal content can *repel* people who are strong in the visual-spatial domain. Lubinski based this assumption, among other things, on the indications that people with pronounced strength in the spatial domain dropped out of studies of all levels more frequently than people whose strength lied in the verbal domain (Humphreys, Lubinski, & Yao, 1993; Lubinski, 2010).

Keeping in mind the observations that continuous texts are dominant in Serbian textbooks and that class notes are also continuous, the question of what form of presenting information would be most appropriate to support students with a high visual-spatial ability in class has been raised. One of the assumptions is that these specificities could be respected by using non-continuous texts. Since there is no standardized reading test in Serbia (Stanković & Lalović, 2010) to test this assumption, I turned to PISA (Program for International Student Assessment) reading literacy units.

Designation of reading literacy in the PISA study

In the PISA study, one of the largest international programs in the domain of education (Pavlović Babić & Baucal, 2009), the emphasis is on functional knowledge and not the reproduction of facts in domains within which the students' achievement is assessed (Baucal & Pavlović Babić, 2010). The major domains used to assess student achievement include reading and mathematical and scientific literacy (Baucal & Pavlović Babić, 2010; Organisation for Economic Co-operation and Development [OECD], 2009a;

Pavlović Babić & Baucal, 2013). The achievements of fifteen-year-old students in each domain are reported on a scale with previously determined average and standard deviation (Baucal & Pavlović Babić, 2010). This scale is divided into levels of functional literacy, and each level is described through the skills and knowledge needed to solve a problem of that level of difficulty (Baucal & Pavlović Babić, 2010, p. 20; Pavlović Babić & Baucal, 2013).

As opposed to interpretations in which literacy is reduced to decoding and literal understanding of the meaning of the written text (Baucal & Pavlović Babić, 2010; Pavlović Babić & Baucal, 2009), in the PISA study reading literacy is understood as "understanding, using, reflecting on and engaging with written texts, in order to achieve one's goals, to develop one's knowledge and potential, and to participate in society" (OECD, 2009a, p. 23). In other words, reading is not seen as a "unitary skill, but as a set of processes, approaches and skills that vary depending on the reader, type of text, as well as the aim or situation in which one is reading" (Pavlović Babić & Baucal, 2009, p. 6). Based on the abovementioned, it is understandable that, in the process of operationalizing reading literacy, attention was paid to the forms in which the text can appear (*text* characteristic), the way in which people approach and use these texts (*aspects* characteristic) as well as the purpose of the text from the perspective of its author (*situations* characteristic) (Baucal & Pavlović Babić, 2010; OECD, 2009a).

As the given key characteristics were further developed into subcategories, one of the criteria based on which different forms of written texts are sorted in the PISA study is the way they are organized, i.e., the text *format* (Baucal & Pavlović Babić, 2010). The basic division into continuous (linear) and non-continuous (nonlinear) texts (Baucal & Pavlović Babić, 2010) is important for this paper, which is why I will give their definitions. While non-continuous texts comprise lists and are characterized by sequential organization, texts consisting of sentences organized into paragraphs, which can form sections, chapters or even books, are considered continuous (Baucal & Pavlović Babić, 2010, pp. 15-16; Pavlović Babić & Baucal, 2009).

The following study is on the topic of the relationship between visual-spatial ability and achievement on PISA reading literacy units. The research was conducted with the goal of testing whether there is an association between the visual-spatial ability and achievement on PISA reading literacy units and, if the association exists, determining its type and intensity. Departing from

the given context of the dominance of continuous texts in the teaching practice, the broader aim of this research is providing recommendations for educational practice and education policy in the domain of textbook production. As the focus of this study is on the people with higher visual-spatial ability, in this research, it is attempted to answer the question of how they perform in PISA reading literacy units of different text formats.

Research method

> H_1 - There is a positive association between the visual-spatial ability and achievement on PISA reading literacy units.

In the abovementioned research conducted in Serbia (Mutavdžin, 2015), a positive, statistically significant correlation was found between the variables used to operationalize the reading skill and visual-spatial ability. Based on these findings, it was assumed that this research would also find a statistically significant, positive correlation between the variables used to operationalize the visual-spatial ability and achievement on PISA reading literacy units, both with continuous and non-continuous text formats.

> H_2 - Participants with higher visual-spatial abilities score lower on PISA reading literacy units with the continuous text format when compared to participants with lower visual-spatial abilities.

Since previous research had found strong indications that the relationship between the visual-spatial ability and reading skill of continuous text is nonlinear (Mutavdžin, 2015), it was assumed that the relationship between visual-spatial ability and reading skill operationalized through achievement on PISA continuous text format units would also not be linear.

> H_3 - Participants with higher visual-spatial abilities score higher on PISA reading literacy units with non-continuous text format when compared with participants with lower visual-spatial abilities.

As I am not familiar with any research in which visual-spatial ability is related to reading non-continuous format texts, this hypothesis is based on logical argumentation (according to Havelka, Kuzmanović, & Popadić, 2004).

Characteristics of the sample

Data was collected on a convenience sample of students in the final grades of three Belgrade elementary schools. The sampling unit was one class, and the sample comprised nine eighth grade classes (three classes from each school). More precisely, 191 14-year-olds were tested. There was no data that any of the students involved in the study had received additional educational support for reading disability.

Variables

Although the method of this study is nonexperimental field research (according to Todorović, 2008), the role of each variable was defined in line with research tradition. The visual-spatial ability was conditionally taken as the independent variable. It is a continuous variable operationalized through general visualization and spatial visualization. Achievement on PISA reading literacy units was conditionally taken as the dependent variable. This continuous variable was operationalized through achievement on PISA reading literacy units with the continuous text format and achievement on PISA reading literacy units with the non-continuous text format. The operationalization of reading reflects the main difference between this research and the study upon which it is based (Mutavdžin, 2015).

The general cognitive ability had the role of the moderating variable; it is also a continuous variable. Introducing general cognitive ability as a moderator is grounded in theory (Carroll, 1993, as cited in Lalović, 2008) and supported by empirical data that it is correlated both with reading (Pavlović, 1994) and spatial ability (Lohman, 1993). Also, according to certain authors (Lazarević & Knežević, 2008), the applied tests of visual-spatial ability also provide measures of general cognitive ability.

The control variables were the participants' sex, the presence of vision correction, familiarity with PISA reading literacy units, as well as experience with different text formats in the school context. This, therefore, acknowledged that the achievement on dependent and independent variables can be influenced by the empirically determined advantage of male participants in certain types of visual-spatial tasks (Linn & Petersen, 1985) and the advantage of girls in PISA reading literacy units, which was determined also in Serbia (Baucal & Pavlović Babić, 2010); untreated visual

impairment (Mutavdžin, 2015); and the experience with different formats of text and familiarity with the administered PISA units. Inclusion of the final listed variable was based on the fact that certain PISA units were published on the webpages of daily newspapers in Serbia (Andrić, 2017; "PISA zadaci," 2012) and the official local *PISA Srbija* webpage (2018). All the control variables are categorical.

Data collection procedures and techniques

Data were collected at the end of the first semester of the 2017/2018 school year. The instruments, which will be presented below, were administered in groups, on the premises of the schools the students attend. Each administering took two school periods (90 minutes).

Visual-spatial ability was assessed using two pen-and-paper tests that are part of the KOG batteries of aptitude tests. The batteries are based on the cybernetic model of intellectual ability by Momirović, Wolf, and Džamonja, and were formed based on the sample of tests taken from other batteries intended for measuring intellectual ability (Lazarević & Knežević, 2008; Wolf, Momirović, & Džamonja, 1992). The S-1 test is part of a shorter, KOG3 battery and, in addition to being used for assessing spatial visualization, it also provides good measurements of the factor of eduction and the general cognitive factor (Wolf et al., 1992). The participants' task is to mark on the answer sheet which of the shown alternatives represents the given model viewed from the direction marked with an arrow. In addition to this, the IT-2 test, which is intended for assessing general visualization, was also used (Wolf et al., 1992). This test is part of a longer, KOG9 battery, and the participants' task is to mark which of the shown three-dimensional shapes will be formed by assembling the given two-dimensional drawing.

These tests have very good metric characteristics (Wolf et al., 1992) and are often used in Serbia by both researchers and practitioners (Altaras Dimitrijević, 2012, 2016). As the KOG batteries of tests are intended for adult participants (Lazarević & Knežević, 2008; Wolf et al., 1992), and considering that the KOG9 battery norms for Serbia have not been published (Altaras Dimitrijević, 2012), this research relied on raw scores.

Achievement on PISA units was assessed using a collection of eight published reading literacy units (OECD, 2009b, 2010a; Pavlović Babić & Baucal, 2009). Half of the PISA units had continuous and the other half non-continuous text

format (introductory stimulus). This ensured that each student gets two scores on the PISA units: one for units with the continuous and the other for units with non-continuous text format. Based on the text format, the units were randomly listed in the workbook given to the students.

After reading the introductory stimulus, the participants answered 18 questions (items) related to the texts. Nine questions followed continuous introductory texts, and nine were related to non-countinuous texts. The number of points that the student could receive for each correct answer was equivalent to the item's level of difficulty. In this way, the students could achieve a maximum of 28 points on each of the scales.

Based on the pilot research conducted on one eighth-grade class, it was concluded that 35 minutes are sufficient for work on these units.

General cognitive ability was assessed with a shortened version of the standard and advanced Raven's Progressive Matrices—the RM-A test (Multiple-Choice Reasoning Test; Pallier et al., 2002). The test comprises 18 tasks for which the participants are given 6 minutes. In addition to selecting which of the shown answers best completes the given set, the participant also needs to indicate on the answer sheet the percentage of their certainty in the accuracy of the given answer. Certainty in the accuracy of the answer was not a variable of interest in this research, and this data was not considered. Still, the prescribed test administration procedure was respected.

An inventory was constructed for the needs of this research, which was used to gather data on the participants' sex, the presence of vision impairment and correction, as well as previous familiarity with the given PISA units.

The adapted Questions about reading for school (OECD, 2008) were used to assess the frequency of working with texts of different formats within the school context. In these questions, students need to indicate how often during the past month they encountered the specified kind of text, along with how often they had to complete a concrete task by reading the specified kind of text.

Presentation of the Collected Data

All data was processed quantitively, using the IBM SPSS Statistics 21 software. The dominant methods of data processing were ANOVA and ANCOVA.

Examining the association between the visual-spatial ability and achievement on PISA units

Pearson's coefficients of linear correlation were used to initially test the existence of an association between visual-spatial ability and achievement on PISA units, both those with continuous and non-continuous text format. The correlations of the dependent and independent variables are shown in Table 1, above the diagonal.

Table 1 *Correlations (Above the Diagonal) and Partial Correlations of the Dependent and Independent Variables (Below the Diagonal; the Controlled Variable is RM-A)*

Measure	**1**	**2**	**3**	**4**
1. Non-continuous PISA units	—	.581**	.423**	.325**
2. Continuous PISA units	.515**	—	.388**	.330**
3. S-1	.244*	.192*	—	.600**
4. IT-2	.064	.075	.402**	—

*p < .05. **p < .01.

Table 1, above the diagonal, shows that all the variables used to operationalize the visual-spatial ability and achievement on PISA units are mutually correlated and that all correlations are statistically significant at the .01 level. Considering the claims that, in the case of positive correlations between the tests, the largest percentage of the variance in the correlation matrix can be explained by the *g* factor, due to the need to control its influence (Lohman, Gambrell, & Lakin , 2008), examining the linear association between the dependent and independent variables was continued by controlling for the effect of general cognitive ability. In Table 1, below the diagonal, partial correlations between the dependent and independent variables, obtained after controlling for the effect of RM-A test achievement, are given. Table 1 shows that, after controlling for the effect of general cognitive ability, correlations between achievement on the S-1 test and achievement on PISA units with both continuous and non-continuous text

format remain statistically significant, although at a lower level of significance, $p < .05$. On the other hand, after controlling for the effect of RM-A test achievement, correlations between achievement on the IT-2 test and PISA units with both formats of text disappeared. Thus, it was concluded that the findings partially confirm the assumed positive correlation between the dependent and independent variables.

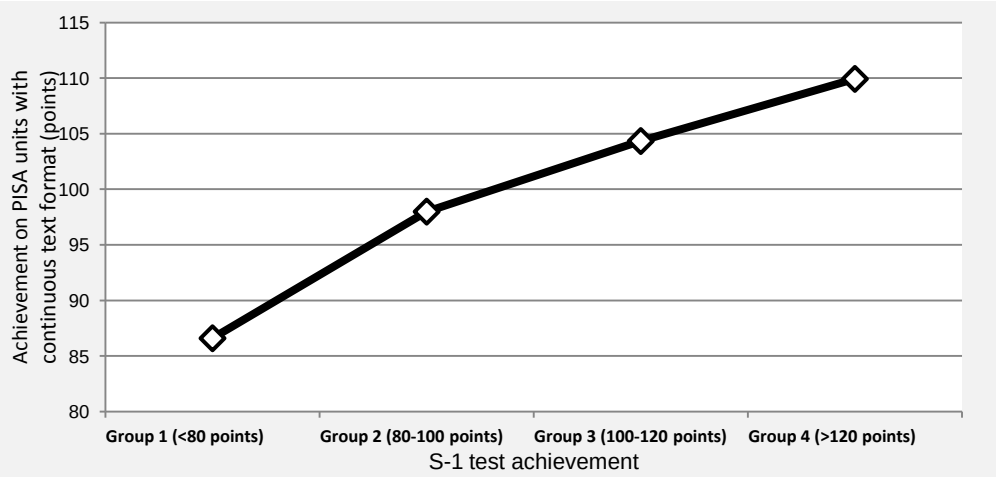
Examining the relationship between visual-spatial ability and achievement on PISA units with continuous text format

In order to ease further analysis and interpretation of the data, the participants' achievements on the numeric variables were standardized, and then transformed into scales with an arithmetic mean of 100, and a standard deviation of 20. The process was conducted for each numeric variable individually. This resulted in five transformed variables that were used in further analyses.

After that, the continuous variables used to operationalize the visual-spatial ability were transformed into categoric ones in order to single out the participants with higher visual-spatial ability. The value of one standard deviation was taken as the sorting criterium. In this way, the achievements of participants on both variables of visual-spatial ability, separately, were divided into four groups: (a) Group 1, less than 80 points; (b) Group 2, from 80 to 100 points; (c) Group 3, from 100 to 120 points, and (d) Group 4, more than 120 points on the transformed scale.

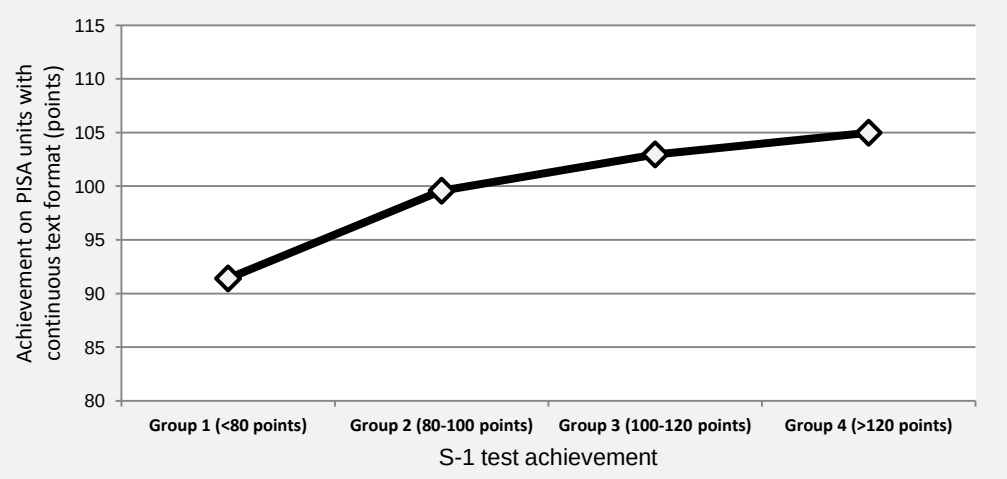
When observing the relationship between S-1 test achievement and achievement on PISA units with continuous text format, after conducting an ANOVA, a statistically significant difference between the groups was determined, $F(3,169) = 9.573$, $p < .001$, $\eta = .381$. The subsequent comparison of achievement among groups revealed that the members of the first S-1 group had lower achievements than both the members of the third and the members of the fourth S-1 group. The difference in achievement on continuous PISA units between the members of the first and the third group was close to the value of one standard deviation (17.737 points on the transformed scale, $t(169) = 4.375$, $p < .001$, $r = .319$), while the difference between the members of the first and fourth group was larger than the value of one standard deviation, exactly 23.325 points on the transformed scale, $t(169) = 4.904$, $p < .001$, $r = .353$. In addition, the members of the second S-1 group had almost 12 points less on the continuous PISA units than the members of the fourth S-1

group (11.936 points on the transformed scale, $t(169) = 2.750$, $p < .05$, r = .207). Based on the polynomial contrast test, it was concluded that the trend is linear, which can be seen in Graph 1.



Graph 1. Relationship between achievements on the S-1 test and the PISA units with continuous text format, obtained via ANOVA.

Group belonging remained statistically significant even after removing the effect of general cognitive ability, through an ANCOVA, $F(3, 165) = 2.770$, $p < .05$, partial $\eta = .219$. The subsequent comparison of achievement among S-1 groups revealed a difference in the achievements on continuous PISA units only between the members of the first and the members of the fourth group.



Graph 2. Relationship between achievements on the S-1 test and the PISA units with continuous text format after controlling for the effect of RM-A test achievement through an ANCOVA.

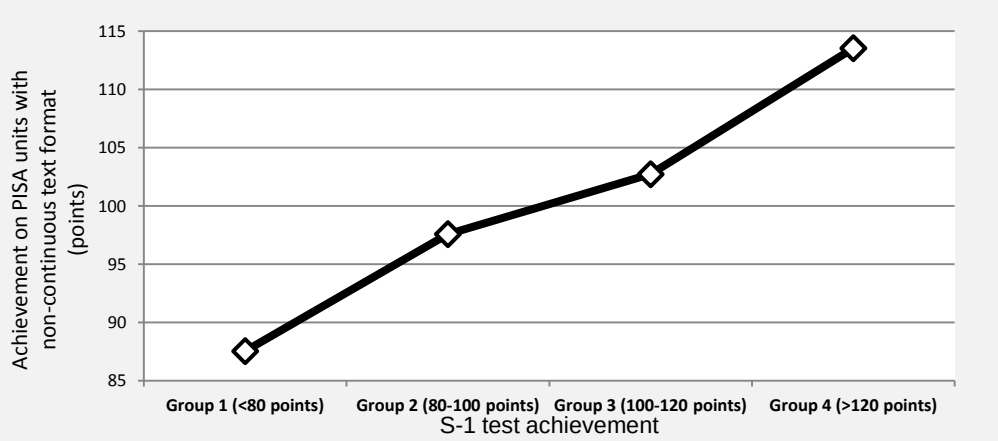
The difference, amounting to a value higher than half of one standard deviation (13.583 points on the transformed scale), is in favor of the members of the group with the highest S-1 test achievement, $t(165) = 2.566$, $p < .05$, r = .196. The trend remained linear, which can be seen in Graph 2.

On the other hand, the statistically significant association determined when the relationship between achievement on the IT-2 test and the PISA continuous format units was observed after conducting an ANOVA, $F(3, 169) = 7.094$, $p < .001$, $\eta = .334$, disappeared after controlling for the effect of general cognitive ability via ANCOVA, $F(3, 165) = 1.318$, $p > .05$, partial $\eta = .153$.

Finally, it can be stated that the presented findings do not support H_2.

Examining the relationship between visual-spatial ability and achievement on PISA units with non-continuous text format

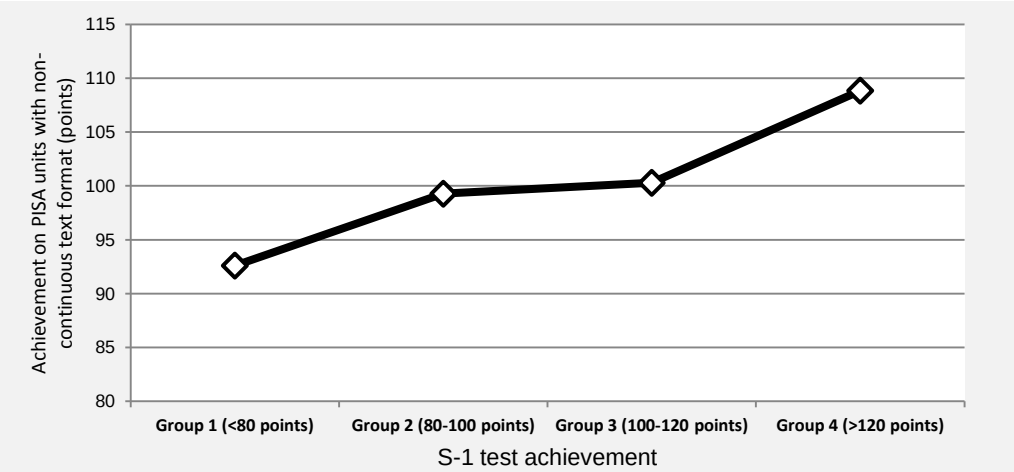
After conducting an ANOVA, it was found that the groups formed based on S-1 test achievement, in total, statistically significantly differ when it comes to achievement on PISA non-continuous format units, $F(3,165) = 10.467$, $p < .001$, $\eta = .400$. The subsequent comparison of achievement among groups showed that the members of the third S-1 group had 15.184 points more than the members of the first group on the PISA units, $t(165) = 3.731$, $p < .001$, r = .279.



Graph 3. Relationship between achievements on the S-1 test and the PISA units with non-continuous text format, obtained via ANOVA.

Moreover, the members of the fourth S-1 group also had more points on the non-continuous PISA units than the members of the first group. The determined difference of 26.005 points surpasses the value of one standard deviation, $t(165) = 5.415$, $p < .001$, r = .388. In addition, a difference of 15.963 points on the non-continuous PISA units was found between the members of the second and the members of the fourth S-1 group, in favor of the latter, $t(165) = 3.635$, $p < .001$, r = .272. The linear trend indicated by the polynomial contrast test can also be seen in Graph 3.

Group belonging remained statistically significant even after removing the effect of general cognitive ability, through an ANCOVA, $F(3, 162) = 3.369$, $p < .05$, partial $\eta = .242$. The subsequent observation of achievement among groups revealed that the members of the fourth S-1 group have 16.240 points more on the non-continuous PISA units than the members of the first S-1 group, $t(162) = 3.166$, $p < .01$, r = .241. The trend remained linear, which can be seen in Graph 4.



Graph 4. Relationship between achievements on the S-1 test and the PISA units with non-continuous text format, after controlling for the effect of RM-A test achievement through an ANCOVA.

When observing the relationship between IT-2 test achievement and achievement on PISA units with non-continuous text format, through an ANOVA, a statistically significant difference between the groups was found, $F(3, 165) = 7.388$, $p < .001$, $\eta = .344$. However, this difference disappeared after controlling for the effect of general cognitive ability, via ANCOVA, $F(3, 162) =$

1.337, $p > .05$, partial $\eta = .155$. Based on the presented results, it can be concluded that H_3 is partially confirmed.

Finally, it should be noted that no difference in achievement was found between male and female participants on any of the measures of the dependent and independent variables. In addition, the sex of the participants also did not affect the relationships between these variables. The same is true for untreated visual impairment. Also, neither previous familiarity with PISA units, nor experience with different formats of texts in the school context, separately, produced a statistically significant difference on the PISA units with continuous and the PISA units with non-continuous text format.

Discussion of the Findings

As in the previous study (Mutavdžin, 2015), statistically significant linear correlations were found between all the used measures of visual-spatial ability and the measures of reading. After controlling for the effect of general cognitive ability, some correlations disappeared, which speaks in favor of the justification for using this variable as a moderator. Still, although lower than the obtained Pearson linear correlations, the partial correlations between achievement on the S-1 test and achievement on PISA units with both formats of text are statistically significant. The nature of this relationship could be additionally explained by including a variable that was not part of this research. Considering that Lohman (2005) points out the diversity in the abilities that make up Carroll's factor of fluid intelligence, maybe different findings would be obtained if the ability of reasoning on verbal material was used as a moderator. Namely, according to Carroll's (1993, as cited in Lalović, 2008) theory, the factor closest to the *g* factor, that is the one most saturated with it, is the mentioned Gf factor. In addition to inductive reasoning, which was here operationalized via achievement on the RM-A test, the Gf factor is further defined by general sequential reasoning (verbal, logical, deductive reasoning) and quantitative reasoning (Carroll, 1993, as cited in Lohman et al., 2008).

On the other hand, observing the partial correlations shows that general cognitive ability affected the association between achievement on the IT-2 test and achievement on PISA units with both formats of text. This claim is further substantiated by the findings obtained when the relationship between achievement on the IT-2 test and achievement on PISA units with both continuous and non-continuous text format were examined via ANCOVA.

For this reason, below, I deal in more detail with the findings obtained by further observing the relationship between achievement on the S-1 test and achievement on PISA units.

The findings obtained after conducting an ANOVA and an ANCOVA attest to a linear relationship between achievement on the S-1 test and achievement on PISA units, which is shown in graphs 1, 2, 3 and 4. Subsequent observations of achievement by groups reveal the statistically significant differences between the achievements of groups with below-average and groups with above-average achievement on the S-1 test, in favor of the latter. In other words, when compared with participants of lower visual-spatial ability, the participants with higher visual-spatial ability had statistically significantly higher achievements on PISA units with both formats of text. In the case of units with non-continuous text format, the determined linear relationship is expected.

The findings obtained by testing the relationship between visual-spatial ability and achievement on PISA continuous format units did not replicate the nonlinear relationship between visual-spatial ability and reading skill (Mutavdžin, 2015). One of the possible reasons for this is the fact that the participants had sufficient time to work on the PISA units. Namely, as opposed to the previously used measure of reading speed, the achievement on PISA units probably provides better insight into the outcome rather than the process of reading. This interpretation is in line with one of the possibilities pointed out by Lohman (1993), which is that "the strength of spatial ability relative to other abilities, particularly verbal and phonemic fluency abilities, may be more important for predicting how problems are represented and solved rather than whether they can be solved" (p. 5). Having this in mind, future research needs to consider whether the used measures of reading address the process or the outcome of the reading.

The fact that the used measures of visual-spatial ability did not reveal the advantage of boys can be interpreted by using the findings of Linn and Peterson (1985), who found that sex differences appear only on certain aspects of visual-spatial ability. On the other hand, this research did not show the well-documented advantage of girls on PISA reading literacy units (Baucal & Pavlović Babić, 2010). There is a possibility that the sample was too small to show stable sex differences.

Finally, although no association was found between achievement on PISA units and experience with different formats of text in the school context, the possibility that informal experience with these formats of text could influence achievement on the used reading units remains (OECD, 2010b).

Limitations of the findings

In line with the need for further research on this topic, several limitations that future research should consider will be outlined.

As the data was collected on a convenience sample, it only reveals the characteristics of that sample, and it is not justified to generalize it. Limitations of the findings were further deepened by the small number of instruments used for the assessment of the dependent and independent variable, as well as the fact that reading competency was assessed by using a collection of published PISA units. Although efforts were made during the construction of the collection to have uniform representations of units with continuous and units with non-continuous text format, they do not represent parallel forms.

Guidelines for further research, the educational process, and educational policy

The discussion section stated a possible explanation as to why the findings did not support the assumption that the relationship between achievement in visual-spatial tests and PISA reading literacy units with continuous text format will not be linear; thus, I will at this point turn to the implications of that explanation. The assumption that a relative strength in the spatial domain can be connected with the way one approaches a problem, rather than their success in solving it (Lohman, 1993), may in the context of this and previous research (Mutavdžin, 2015) imply that people with higher and people with lower achievements in the visual-spatial test approach reading units differently. To be precise, it is possible that, due to their different approach to the text, people with higher visual-spatial ability are more prone to read the text at a slower pace, which was found in previous research (Mutavdžin, 2015). In addition, as the testing showed that students had sufficient time to work on the PISA units, in line with the abovestated it should be pointed out that students need to have sufficient time to work on more complex reading units. Regardless of the findings of further research and concrete classroom interventions, in everyday life students will come

across texts of different formats whose reading requires different sets of knowledge and application of different reading strategies (Baucal & Pavlović Babić, 2010; OECD, 2009a). This is why students need to be provided with learning materials that include texts with both continuous and non-continuous formats. It is the author's belief that the legislature related to standards that textbooks in Serbia should meet (Pravilnik o standardima kvaliteta udžbenika, 2016; Pravilnik o dopuni Pravilnika o standardima kvaliteta, 2018) should more explicitly support the implementation of the non-continuous texts by pointing out that some of the text segments can be more adequately presented in a non-continuous format.

Broader implications of this research

A confirmation of the need to connect research and practice was obtained in the field. More precisely, because of the interest of the school staff, but also that of the students and their parents, the collected data was mostly used as part of the students' professional orientation (which is in line with the recommendations of the authors of the KOG3 battery, according to Wolf et al., 1992) in order to inform them of their strengths. Additionally, the documents developed as part of the PISA research, along with all the published units, were distributed to the subject teachers and associates who requested them. This approach is in line with views on the possibility that, in the absence of formal training and system support, this is a way for teachers to gain insight into "how the student competencies that students from Serbia have not yet mastered are expressed and assessed" (Pavlović Babić, 2013, p. 168). In addition, certain schools expressed the wish to have their staff presented with information on the dependence between student achievement and unit characteristics, as well as with guidelines for practice.

Considering this experience and the cited views, the conclusion is that there is a need to find a system solution for the cooperation between the different educational professions. The cooperation thereby needs to be continuous and available to all those interested. If not, as often stated in the warnings, the cooperation will remain occasional and reserved for schools in the capital, Belgrade.

Conclusion

This study, which I view as one branch of a broader topic, aimed to point out that the students' characteristics can best be supported in the classroom if the

teachers are provided with empirically grounded work guidelines and if these guidelines inform the education policy, primarily in the domain of producing textbooks. The obtained findings attest to a linear relationship between the operationalized dependent and independent variable. Further research needs to be conducted in order to examine the set out hypothesis and to provide more specific guidelines for educational practice.

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