POSSIBILITIES OF COMPUTER-BASED ASSESSMENT IN VISUAL ARTS EDUCATION

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To cite: BABÁLY, B. (2016). Possibilities of computer-based assessment in visual arts education. In *SGEM International Multidisciplinary Scientific Conference on Social Sciences and Arts, performing arts, architecture and design: History of Arts, Contemporary Arts, Performing and Visual Arts*, *Conference proceedings* (pp. 167-174). Vienna, Austria, 6-9 April 2016. Szófia: STEF92 Technology Ltd. (ISBN: 978-619-7105-53-7)

ABSTRACT

This study explores the advantages of computer-based assessment in visual arts education. It outlines a model of spatial abilities and shows an online testing tool for its assessment. Tests were piloted in different regions of Hungary, in school grades 4-8. (N=1189) In multiple iterations, eight test types were applied with altogether 62 tasks of different difficulty level, targeted to the skills of the five school grades. The test system proved to be a motivating and comprehensive assessment method to define the developmental level of a wide range of spatial skill components. I discuss factors influencing the perception and interpretation of space and present strategies of pre-adolescents (ages 10-14 years) in solving spatial problems.

Keywords: computer-based assessment, spatial abilities, visual competences, art education

Introduction

Computer-based tests in educational assessment provide convenient data management, immediate feedback about the achievement and great opportunities to explore new types of skills and abilities. [2] Research reported here is a part of the *Developing Diagnostic Assessment*[1] project of Szeged University, co-ordinated by the Center for Research on Learning and Instruction. It involves the development of the standards of the three main fields of literacy (reading, mathematics and science) and fourteen further fields that academically establish the diagnostic assessments. Our research group[2] identified visual skill components, developed and piloted a set of paper-based and digital tasks in the *Visual Literacy* sub-project. [6], [7] The best tasks were included in eDIA (*Electronic*

[1] Official site of the *Developing Diagnostic Assessment* project: http://edia.hu/?q=en/index (Page last opened on 24 February 2016)
[2] Lead researcher in the *Visual Literacy* research group is Andrea Kárpáti. Further information is available at http://edia.hu/?q=en/exploring_the_possibilities_of_diagnostic_assessment (Page last opened on 24 February 2016)

Diagnostic Assessment System)[3], the online and interactive testing environment of the project.

Characteristics of the eDIA environment:

- *Online, adaptive* and *motivating* testing environment
- *Free* and *easy* availability for schools for development and assessment all over Hungary
- *Immediate, personalized feedback* on knowledge and skill levels of learners
- Tests and tasks for student aged 6-12 (Grades 1-6 , ISCED level1)
- *Wide variety of item types* with sound, image, video and animation
- *Response in different forms* (e.g.: marking, clicking, colouring and rearranging images, entering text, pairing text and picture)

In the present phase, our research group investigates two components of visual skills: visual communication and spatial abilities. In this paper, I give a brief account of the first results from my research into spatial abilities assessment practices.

Assessing spatial skills: traditional and innovative methods

Representing space has traditionally been considered a basic set of skills that involved a central place in the training of the artist. Traditional methods of developing and assessing spatial skills at the art academies as well as architects' studios of the 19th and early 20th century involved perspective drawing, copying gypsum models of Classic works of art, studying geometric shapes and drawing floor plans and section plans. [9] As an indication of the central role of spatial skills in a variety of trades and professions, geometric drawing was introduced in public education in the last decades of the 19th century, as part of the discipline of Mathematics, later also of Fine Arts. [5]

With regular art instruction included, school curricula of the 20th century developed two distinct clusters of spatial abilities: geometric construction and artistic creation. Loosely interrelated, these two methodologies still targeted the same objective: preparation for certain professions. [13] A variety of tests were developed to assess perception and mental manipulation of space [1], [12] and it was also identified as a major component of visual talent. Cognitive skills like reasoning were also found to have connections with the level of spatial orientation. [11]

Interdisciplinary studies of arts and science education indicate the importance of visualisation of spatial relations in solving mathematical problems. "Findings indicate that level of spatial understanding and use of schematic drawings both were significantly correlated to problem solving performance. Findings from this research

[3] Official site of the eDIA (*Electronic Diagnostic Assessment System*): http://edia.hu/?q=en/elaboration_of_the_electronic_diagnostic_assessment_system_eDIA (Page last opened on 24 February 2016)

have implications for policy and practice. The art classroom is an important context for developing students' spatial understanding and proportional thinking abilities associated with artistic as well as mathematical ability.” [3] In a paper with the metaphoric title, “Spatial ability and STEM: A sleeping giant for talent identification and development”, David Lubinsky (2010) advocates for the integration of the development of visual culture and science disciplines. “Spatial ability is a powerful systematic source of individual differences that has been neglected in complex learning and work settings; it has also been neglected in modelling the development of expertise and creative accomplishments. Nevertheless, over 50 years of longitudinal research documents the important role that spatial ability plays in educational and occupational settings wherein sophisticated reasoning with figures, patterns, and shapes is essential. Given the contemporary push for developing STEM (science, technology, engineering, and mathematics) talent in the information age, an opportunity is available to highlight the psychological significance of spatial ability.” [8]

Visualisation and observation of space also play an important role in everyday life. Authentic assessment of skills used in manipulating a large car into a narrow parking space, finding our way around with the help of a map or verbal instructions, reconstructing a broken object or buying furniture to fit in a living space require tasks that are contextualized rather than abstract. Children can perform operations with three-dimensional objects from the age of 9-10. [10] Time constraints and financial limitations, however, make authentic assessment difficult.

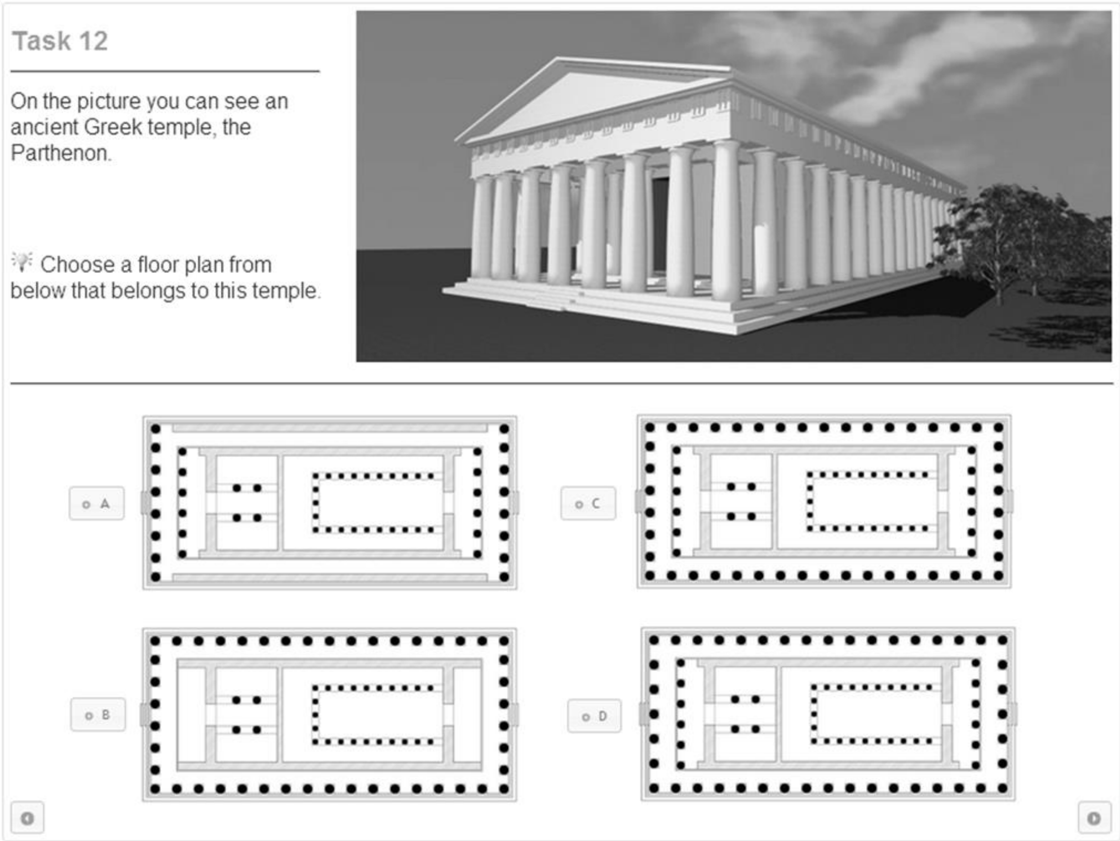

Figure 1: A "*Spatial reconstruction*" task from the eDIA online testing environment. (Screenshot)

Aims of research

The objective of this study is twofold. First, I explore the possibilities of a technology-based assessment and automatic scoring process in art education. In addition, I investigate factors influencing the perception and interpretation of space.

Sample and assessment instruments

I piloted the first version of the tests with 413 students, almost equally distributed between Grades 4, 5 and 6 in primary schools in Hungary. For about half of the groups, tests were administered online, using the eDIA testing environment, for the other half, on paper. After these pilots, spatial skills of a *national sample of 633 students from Grades 4, 5, 6, 7 and 8 (ages 10-14 years) from 14 schools* were assessed with the corrected measuring instruments between March and June 2014. (The sample included 163 students from 4th Grade, 161 students from 5th Grade, 104 students from 6th Grade, 195 students from 7th Grade, and 10 students from 8th Grade.)

To improve content validity, I analyzed current psychological measures of spatial abilities as well as Hungarian curriculum objectives and related tasks. (An example: I included mental rotation and transformation because it is a standard feature in intelligence tests and are also considered basic for understanding descriptive geometry). Young adolescents (aged 10-13) have rarely been examined in this area, so I had to make adaptations of existing task types. (For example, for any single task, mental rotation is required in one direction only.)

After the identification of spatial abilities and related knowledge relevant for the age groups targeted, I developed 62 tasks and their scoring guides and embedded them in our national online testing environment, eDIA. The spectacular visual appearance of the tasks of eDIA makes it an enjoyable visualisation tool that makes it easier to comprehend spatial problems than black-and-white, abstract axonometric projections in traditional paper-based tests. During electronic assessments, students work in an environment that resembles social web sites as well as gaming applications. Task response types include marking, coloring and moving images, entering text, joining text and picture or forming groups of items. In the “Visual Literacy” task package, I provide practice items that show manipulation options and also a voiceover for slow readers. Digital images provide a life-like representation of space and reproduce complex spatial situations accurately. Time for the solution was recorded and one testing process was planned to involve a maximum of one lesson hour (45 minutes).

The tasks target four clusters of spatial skills:

1. *Spatial positions, relations, direction*: here students are invited to orientate in a virtual space that imitates a real-life, built environment. To solve spatial problems they have to perceive distances, sizes of objects and determine their position in this space compared to the objects. (See Figure 2 for examples.)

2. *Comprehension of structures of three-dimensional shapes*: cognition of spatial shapes and their concave-convex extensions, perception of covered bulks, observation of regular-irregular spatial structures, comprehension of connection among structural elements. These skills are basic for a wide range of vocations and professions. If detected early, deficiencies can be developed with success.

3. *Spatial reconstruction*: students have to recognise three-dimensional spatial situations visualized in two-dimensional images (projection drawings, section planes, ground plans, front elevations and pictograms). (See Figure 1 for examples.)

4. *Spatial transformations, manipulations*: this cluster requires mental operations like cutting, rotation, removal, mirroring, assembly and construction.

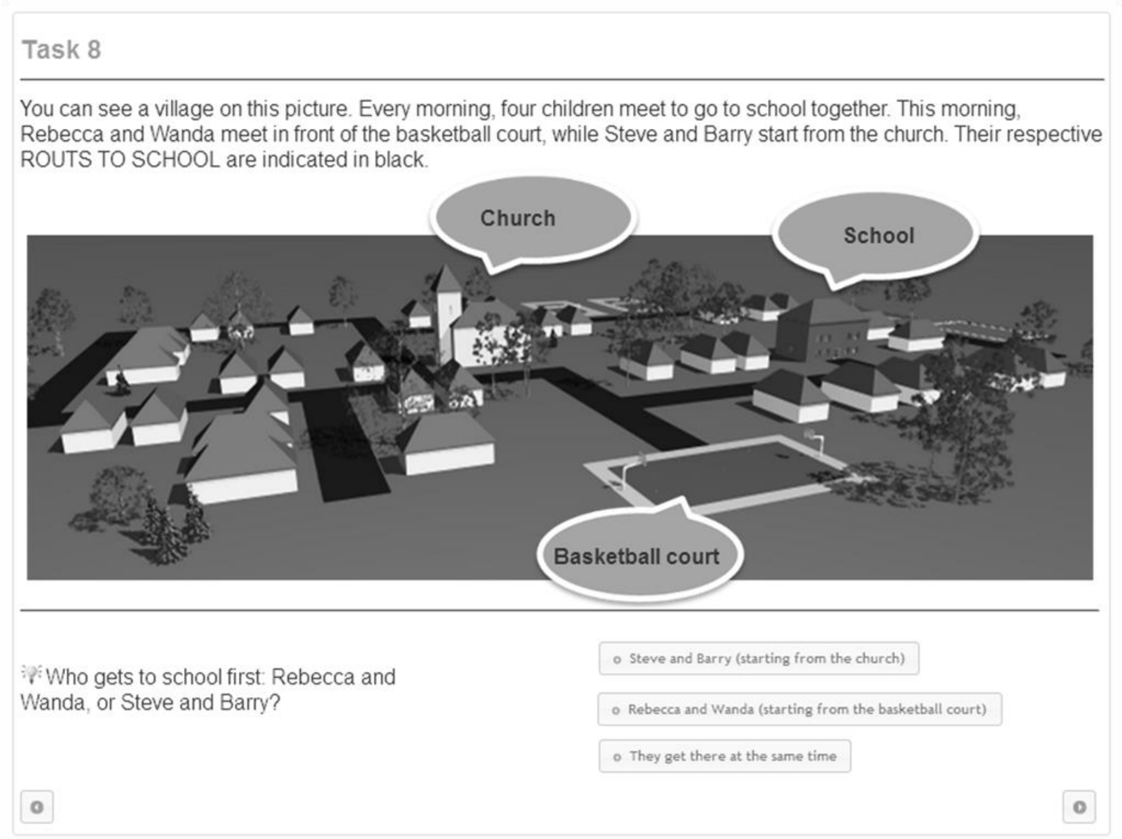

Figure 2: Estimating distance in virtual space (age: 10-11 years). A task from the eDIA online, interactive Hungarian testing environment. (Screenshot)

Results

No significant differences were found between paper based and web based test results with regard to group average, maximum score, scope and deviation. Results show a normal distribution, test solutions (in percentage points) are between 4% and 100%. Average achievement is 55,54 percentage points, with a deviation of 19,71. Students easily solved spatial problems that they encounter in their everyday life, like estimating distances and orientation using map. (Test results are summarized on Figure 3 according to the four clusters of spatial skills.) On Figure 4, results of mental operation tasks are shown. These tasks seemed simpler if they were associated with recognizable shapes. Most of students found spatial operations with abstract geometrical forms too difficult.

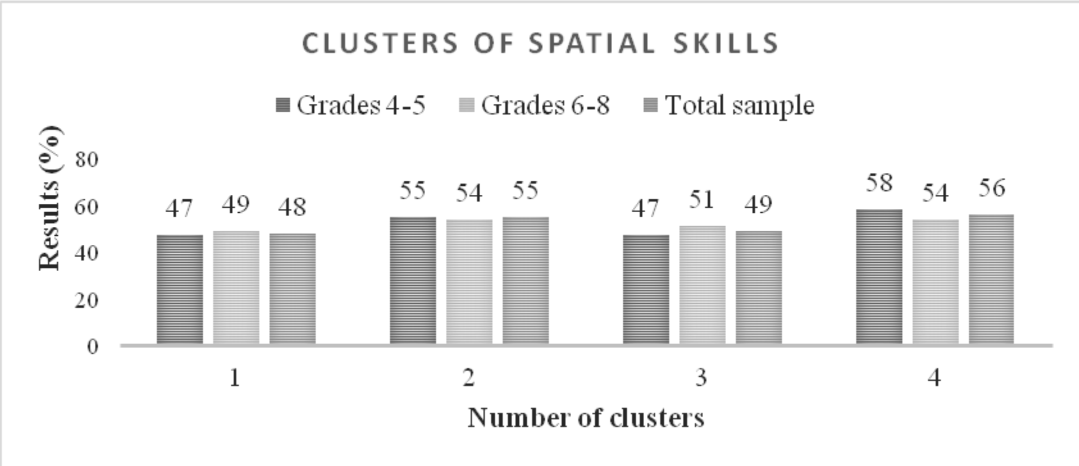

Figure 3: Results of the grades in the four clusters of spatial skills (N=946)

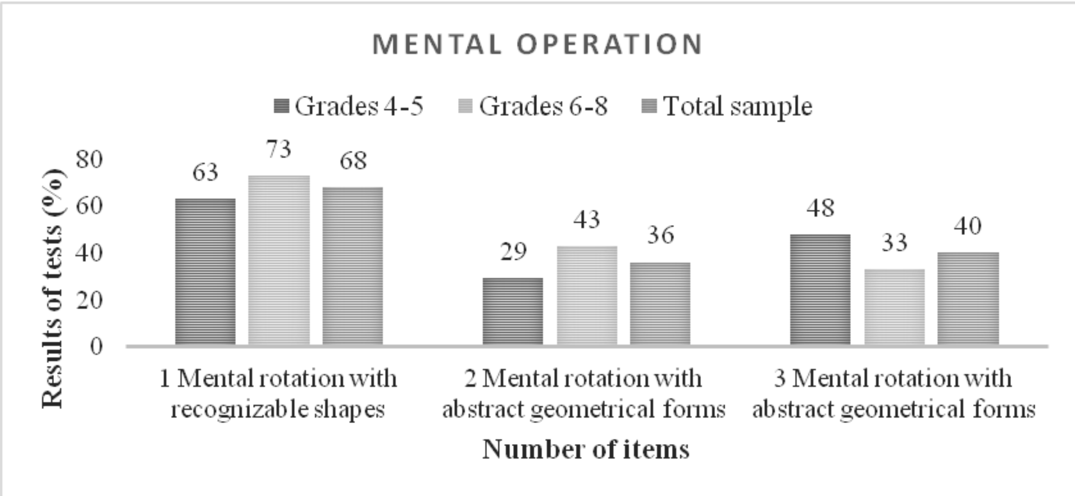

Figure 4: Results of the grades in the mental operation tasks (N=946)

Through a factor analysis of data, I controlled the hypothetical structure of spatial skills. Factor analysis was performed on 10 tasks of the test version “A” (for Grades 4 and 5) and on 10 tasks of the test version “B” (for Grades 6). The assessment instruments for spatial skills proved to be reliable. The Cronbach's alpha coefficient for test version “A” is 0.79. The inter-task variance of the factors of test version “A” is 69.43. Based on communality values, four spatial ability factors were identified*: (1) Mental rotation, (2) Interpretation of spatial structures and shape characteristics, (3) Spatial orientation, (4) Estimating distance*. The Cronbach's alpha coefficient for test version “B” is 0.81. The inter-task variance of the factors of test version “B” is 67.08. Based on communality values, three spatial ability factors were identified*: (1) Mental operation with abstract forms, (2) Mental operation in lifelike spatial situations, (3) Estimating sizes*.

The development of cognitive skills (e.g.: analyzing, comparing, abstraction capability) influenced the performance of students. In general, the tests of varying difficulty items are capable assess spatial abilities of children differentially.

Conclusion

Results suggest that spatial abilities may be reliably assessed in age groups rarely targeted by visual skills studies. Through an authentic, lifelike formulation of tasks, spatial skill components like mental rotation and transformation that had previously been identified and measured from age 13 only, may be reliably assessed in ages 10, 11 and 12 already. Analyses of results revealed factors influencing the perception and interpretation of space: (1) complexity of mental operations, (2) extent of abstraction (shapes and spatial problems), (3) development of cognitive skills. These data will hopefully be utilised in developmental programs in art education as well as other areas of studies, focusing on this set of important basic skills for a variety of professions. The test battery may be used in disciplines fostering spatial abilities and is among the first digital test collections for visual arts education in Europe.

In eDIA, results of Visual Literacy may be compared with three core disciplines (Mathematics, Mother Tongue, Science) as well as thirteen other areas of studies (including musical skills, creativity and problem solving) to reveal correlations and cognitive, affective and psychomotor gains resulting from education through art. Another major issue of research will be the comparison of creation with digital and traditional tools. Do we lose important aspects of creation and perception if we substitute paper and pencil (or paint) with digital tools? What is the role of multimedia in the contemporary visual language of children? (A new research has revealed its important impact, [4]).

In its final form, the eDIA-system will monitor personal development, offer tasks for individual skill enhancement based on previous results. Art teachers may thus design individualized teaching-learning processes that supports talent development and caters for special needs (like mental or psychomotor deficits) at the same time.

ACKNOWLEDGEMENTS

Research reported in this paper is supported by the *Development of Diagnostic Assessment Project*, co-ordinated by the Research Group on the Theory of Education of Szeged University. (Project No. TÁMOP-3.1.9-11/1-2012-0001) I would like to thank Professor Andrea Kárpáti (Eötvös Loránd University, Faculty of Science) for her expert advice and support throughout in this project.

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