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Validation of a diagnostic tool for identification of pre-schoolers and primary pupils with science talent

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Abstract

The paper focuses on validation of a diagnostic tool for identification of naturalist intelligence and science talent at pre-school and early school level (Jančaříková, 2009). The theoretical part explains the significance of early identification of science talent and introduces briefly Howard Gardner's theory of multiple intelligence and naturalist intelligence as the starting point. The empirical part validates the diagnostic tool on the basis of data from 176 completed questionnaires. The reliability of the test is verified using the Cronbach Alpha coefficient and Spearman-Brown formula. The Pearson correlation test confirms a high interdependence of the questions in the diagnostic tool. The Welch variant of the t-test shows that the results depend on neither gender nor age, which can be interpreted as depending on an innate disposition, i.e. science talent. Thus, the diagnostic tool can be used for early identification of science talent.

Key words

Naturalist intelligence, theory of multiple intelligences, science talent, diagnostic tool for identification of naturalist intelligence/science talent, gifted children

Abstrakt

Příspěvek je věnován ověřování diagnostického nástroje pro identifikaci přírodovědně nadaných v předškolním a v mladším školním věku (Jančaříková, 2009). V teoretické části vysvětluje význam rané identifikace přírodovědného nadání a stručně představuje teorii přírodovědné inteligence Howarda Gardnera jako výchozí koncept. Ve výzkumné části bylo provedeno ověřování diagnostického nástroje na základě 176 vyplněných dotazníků. Reliabilita testu byla ověřena pomocí koeficientu Cronbachovo Alpha a Spearman-Brownova vzorce. Pearsonovým korelačním testem byla prokázána vysoká vzájemná závislost otázek diagnostického nástroje. Welchovou variantou t-testu bylo prokázáno, že výsledky nezávisí na pohlaví ani věku, což lze interpretovat, že závisí na vrozené dispozici, tedy přírodovědném nadání. Diagnostický nástroj lze pro ranou identifikaci přírodovědného nadání používat.

Klíčová slova

Přírodovědná inteligence, teorie rozličných inteligencí, přírodovědné nadání, diagnostický nástroj pro identifikaci přírodovědného nadání (přírodovědné inteligence), nadané děti

Introduction

European society is currently striving to improve science education. This is done in two ways: a) by development of science literacy, b) by identification of future professionals - natural scientists who will be able to make professional decisions on science issues in social contexts (Janík, Stuchlíková, 2010: 13, Eilks at al., 2004).

This paper focuses on the latter issue, i.e. on identification of children and younger pupils with the potential of becoming natural scientists. In this endeavour, the paper builds on the previously published paper *Přírodovědná inteligence: diagnostika a péče o přírodovědně talentované žáky a studenty v ČR* (*Naturalist Intelligence: Diagnostics and Care for Children and Pupils with Science Talent in the Czech Republic* (Jančaříková, 2009) and on pedagogical activity of the author, including popularization activities (e.g. Jančaříková, 2011 and 2012).

Only a small proportion of the population has innate dispositions to become a natural scientist, as this talent is sparse in population (Wilson, 1997). Not enough attention is paid to identification of this talent, at least in the Czech Republic.

Different abilities of individuals from the same age group to solve problems are explained by intelligence theories. Allegedly, the first person to use the concept of intelligence for this purpose was the scientist and inventor, Charles Darwin's cousin, Francis Galton (1822-1911). Intelligence is most often defined as the ability to adapt to new life challenges and to think actively about new stimuli. Or, as the ability to process information, whereby we understand everything perceived by a person by their senses (Hříbková, 2005, Gardner, 1993). There are different concepts of intelligence, such as the theory of global intelligence, the theory of multi-factor intelligence or hierarchical theory of intelligence, the theory of emotional intelligence, the theory of fluid intelligence, the theory of distributed intelligence (for example, Ruisel, 2000, Mackintosh, 2000, Jančaříková, 2015). The theory that is most suitable for the needs of describing mental abilities needed to solve natural science and environmental problems is the theory of multiple intelligences of the American psychologist Howard Gardner. One of the eight components of the intelligence spectrum that Gardner defines is naturalist intelligence. Gardner amended it in 1996 as the eighth intelligence to the previously created spectrum of seven intelligences, which was verbal-linguistic, logical-mathematical, musical-rhythmic, visual-spatial, bodily-kinesthetic, interpersonal, intrapersonal (Campbell, 1997, Gardner, 1993).

Naturalist intelligence is characterized by Gardner as the ability to observe, understand and classify natural entities. The person who becomes a natural scientist – experts such as Charles Darwin, Carl von Linne, Gregor Mendel, James Watson, Francis Crick, Rachel Carson and Dmitry Ivanovich Mendeleev – is the person who can recognize and classify plants, animals, and inanimate objects (including molecular-level life) more easily and better than others and who perceives their connections to the environment (Campbell, 1997, Jančaříková, 2009, 2015).

For didactics of natural sciences, the moment of defining naturalist intelligence was a significant cornerstone. It opened the way to discussions on science talent, its manifestations and on the needs of scientifically gifted pupils. Bearing in mind that every theory is just a theory and its application to practice can describe reality inaccurately, as Gardner himself points out (1993), the theory of naturalist intelligence was used as the basis for understanding a specific group of children and pupils.

The theory of naturalist intelligence is based on the assumption that individuals are born with different dispositions for development of a relationship to nature, just as they are

born e.g. with different musical talents. Obviously, it would be possible to talk about science talent or highly developed natural science literacy. However, the concept of naturalist intelligence is so sophisticated that it seems advantageous to work with it and base on it other considerations. Science intelligence must be distinguished from biophilia[1] and environmental sensitivity[2], which are other perspectives on the relationship to nature that teachers should be aware of.

First and foremost, it is essential that teachers be able to identify a science talent and then support development of scientifically talented children or pupils in appropriate ways.

Ten years ago, I created a tool for identification of naturalist intelligence in pre-school children and primary school pupils. I came out of two international studies (Campbell, 1997, Meyer, 1997) and long-term experience from running extracurricular science clubs for scientifically gifted pupils. The initial version of the tool was slightly modified on the basis of five focus group discussions with combined study pre-service kindergarten teachers and of five focus group discussions with combined study pre-service primary school teachers at the Faculty of Education, Charles University in 2007-2009. The final version of the tool was published in a scientific (Jančaříková, 2009) and popularizing (Jančaříková, 2011) papers and started to be used by teachers in the Czech Republic (more than 10,000 views of the popularizing paper on the RVP Portal for teachers by 1st March 2019).

Methodology

The aim of this paper is to present the results of validating the above-mentioned diagnostic tool for identification of naturalist intelligence.

For these ends, the following research questions were asked:

1. Are the questions included in the diagnostic tool relevant?

2. Are the answers dependent on the age of the respondents (children and pupils)? (If first graders at primary school had on average a higher score on the test, the diagnostic tool itself would have to be questioned because it would diagnose experience not intelligence.)

3. Are the answers dependent on children's and pupils' gender?

4. Which questions have higher and lesser scores?

Based on the research questions, the following three hypotheses were formulated:

[1] The concept of biophilia is based on the belief that everyone is born with love for (and bond to) nature, but in some people this love is not sufficiently developed and therefore disappears or even transforms into biophobia (Kahn, 1997; Kellert and Wilson, 1993 in Franěk, 2000).

[2] The emotional aspect of the relationship to nature, sensitivity to nature, to living creatures and to landscape, in other words the personality component of character (Wilke, 1993). Environmental sensitivity is born as a response to a greater number of more or less important experiences through a complex interaction between a number of life experiences and their interpretation by a particular individual (Franěk, 2004).

The 1st question was transformed to hypothesis H1 – "The question does not depend on the score without this question". The alternative hypothesis is "The question is dependent on the score without this question". This hypothesis was tested for each of the questions individually.

The 2nd question was transformed to null hypothesis H2 – "The average score is the same for groups younger than 6 and older than 7" in contrast to the alternative "The average score is different".

The 3rd question was transformed to null hypothesis H3 – "The average score is the same for boys and girls" in contrast to the alternative "The average score is different".

The 4th question did not require formulation of a hypothesis. It was enough to arrange the results according to this criterion.

Data collection was insufficiently proven with the help of teachers - students of combined study at the Faculty of Education, Charles University. Each task was to select two pupils from their classes.

Results

A total of 176 completed questionnaires was obtained from the target group of respondents, i.e. pre-school children and primary school pupils. The diagnostic tool for naturalist intelligence was also filled in (following given guidelines) by teachers based on their knowledge of the children and pupils and on interviews with them (if necessary also with their parents).

The reliability of the test was checked using the Cronbach Alpha coefficient and Spearman-Brown formula. Both tests show a high degree of internal consistency. Cronbach Alpha is 0.925 and Spearman-Brown formula 0.928. This means the construction of the test meets the common requirements and guarantees sufficient validity of the test (slightly above 96%).

In the following step, a detailed analysis focusing on effectiveness of individual questions included in the test was conducted.

Correlation coefficient*	average	question number	question
0.91	**4.23**	**3**	likes being outside, loves outdoor activities such as gardening or going for walks, trips to the nature and its observing or excursions
0.92	**3.88**	**1**	finds it easy to classify and categorize objects
0.99	**3.74**	**6**	is interested in and looks after plants and animals
0.95	**3.70**	**2**	has highly developed senses (sight, hearing, smell, taste and touch) and uses them to explore nature
0.93	**3.51**	**5**	is unusually attentive to changes taking place in his / her surroundings
0.95	**3.45**	**4**	prefers work with natural material to work with artificial materials
0.97	**3.43**	**17**	prefers going to the Zoo to going to theme parks
0.98	**3.36**	**12**	is a patient observer
0,95	**3.36**	**15**	favours natural environment to cultivated environment
0.98	**3.34**	**10**	finds it easy to learn characteristic properties, names, systems and information about plants, animals or products of nature
0.97	**3.34**	**16**	repeatedly visits some particular natural environments (has favourite places and likes talking about them)
0.97	**3.22**	**14**	experiences love for a particular place, ecosystem or ecosystems (sea, forest, desert, marshland, etc.); in other words "has their secret spot"
0.97	**3.11**	**9**	from an early age is very interested in television programmes, videos and books on natural science
0.98	**3.05**	**13**	feels and is aware of relationships and bonds to nature and in nature
0.99	**3.01**	**20**	engages recreationally in outdoor, non-competitive activities (e.g. hiking, climbing, fishing, canoeing, sailing, cross-country skiing, outdoor camping, diving)
0.97	**2.71**	**11**	is interested in and understands cyclical phenomena (moon phases, high tide and low tide, seasons, etc.)
0.95	**2.51**	**18**	learns to draw or photograph nature and products of nature because he/she has the desire to capture in picture what he/she observes in nature
0.96	**2.35**	**7**	makes collections (herbarium, collection of butterflies, beetles, stones, cones, shells, etc.)
0.92	**2.34**	**19**	likes reading books about nature and about tramping (for example books by A. Ransome, E. Štorch, V. Bianki, O. Sekora, J. Foglar, J. Tomeček. G. Durrell, J. Adamson)
0.95	**1.82**	**8**	cuts out information about nature from magazines or/and writes down his/her observations (takes notes or keeps a diary)

Tab. 1: * Correlation coefficient between the score in the given question and the average score without this question is approaching 1 in all the questions. This signals a high level of interdependence. The questions are put in the order of the average score from the highest to the lowest, which answers the 4th research question.

The H1 hypothesis test followed * the correlation coefficient between the score in the given question and the average score on the test without the given question. Values of this coefficient are in the range between -1 to 1. Values close to 1 mean high interdependence,

values close to zero low interdependence. The correlation coefficients for all questions on the Diagnostic Tool for Identification of Naturalist Intelligence are approaching 1 (see Table 1), which means high interdependence of questions. For all questions, the H1 hypothesis at 0.05 was rejected. This means each question correlates with the score on the test without the question. In other words use of each of these questions in the diagnostic tool is justified. There is no need to exclude any of the questions. The test was conducted with the Pearson correlation test.

In hypotheses H2 and H3, we assumed there was a selection of two independent normal distributions with the same mean value. The test of null hypothesis H2 at the level 0.01 showed that the null hypothesis could not be rejected at this level; p = 0.792. Therefore, the results do not depend on the age of the diagnosed child or pupil. The test of zero hypothesis H3 at the level 0.01 showed that the null hypothesis could not be rejected at this level; p = 0.128. Therefore, the results do not depend on gender. The test was conducted using the Welch t-test variant. The results do not depend on gender or age. This can be interpreted as dependence on an innate disposition, that is science talent or naturalist intelligence (see Figure 2).

Average score							
	Gender			**Age**			**In total**
	Boys	**Girls**	**unknown**	**older than 6**	**younger than 6 (including 6)**	**unknown**	
Number	92	**69**	15	54	50	72	176
Average	63.03	63.72		66.50	61.46		63.35
SE*	17.79	15.26		16.83	16.63		16.82

Tab. 2: Test of null hypothesis H2 and null hypothesis H3 (SE* = standard deviation) proves that the score gained on the diagnostic tool is dependent neither on gender, nor age.

Discussion

Not enough attention is paid to identification of naturalist intelligence (Havigerová, 2011).

The only theory of intelligence that also focuses on science talent and scientifically gifted children and pupils is the theory of multiple intelligences of Howard Gardner. Although this theory is not generally accepted and there are a number of critics who favour other theories of intelligence, it seems useful for science education. However, anyone building on it should be aware that, as Howard Gardner states himself, sub-intelligences, i.e. also naturalist intelligence, do not exist “tangibly”. If we talk about them we must be aware that we reificate (Gardner, 1993: 90).

In any case, science talent and support of scientifically gifted children and pupils from a very early age deserves more attention. The Diagnostic Tool for Identification of Naturalist Intelligence may be one of the tools for achieving this.

It should be noted that this questionnaire, which was created by a compilation of two foreign works (Jančaříková, 2009), follows rather general interest in nature and outdoor activities. They are not interested in chemical or physical experiments. We could say that it is not fair to the natural scientists of the so-called "white coats", ie those who investigate natural phenomena in laboratories. In the future, it seems appropriate to consider developing additional questions or separate diagnostic tools to address this.

The answer to the alternative hypothesis to H1, which points at a high level of interdependence of questions, also means that each of the questions could be left out from the test and the test would be equally relevant. If this was needed e.g. because of time constraints, left out should be questions with lower average value, i.e. the final items in Table 1.

Conclusion

The diagnostic tool for early identification of naturalist intelligence, published ten years ago, has been tested and validated. Its use can really help to identify children and pupils with higher naturalist intelligence or science talent. The reliability of the test was verified using the Cronbach Alpha coefficient and Spearman-Brown formula (both show high internal test consistency). There is no need to exclude any of the questions. The Welch variant of the t-test has shown that individual items of the diagnostic tool are not dependent on age and gender. This confirms the assumption that the used questions really capture an innate disposition, not for example an experience that grows with age. Similarly, gender dependence was ruled out.

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Appendix

Diagnosing science talent according to Jančaříková (2009) Each item gets the score from 0 to 5 expressing the degree of the described phenomenon (5 is the highest) in the diagnosed child/pupil.		
No.	Interests, manifestations and acting of the pupil (name, age):	score
1.	finds it easy to classify and categorize objects	
2.	has highly developed senses (sight, hearing, smell, taste and touch) and uses them to explore nature	
3.	loves outdoor activities such as gardening or going for walks, trips to the nature and its observing or excursions	
4.	prefers work with natural material to work with artificial materials	
5.	is unusually attentive to changes taking place in his / her surroundings	
6.	is interested in and looks after plants and animals	
7.	makes collections (herbarium, collection of butterflies, beetles, stones, cones, shells, etc.)	
8.	cuts out information about or photographs of nature from magazines or talks about and writes down his/her observations (takes notes or keeps a diary)	
9.	from an early age is very interested in television programmes, videos and books on natural science	
10.	finds it easy to learn characteristic properties, names, systems and information about plants, animals or products of nature	
11.	is interested in cyclical phenomena (moon phases, high tide and low tide, seasons, etc.) and understands them	
12.	is a patient observer	
13.	feels and is aware of relationships and bonds to nature and in nature	
14.	experiences love for a particular place, ecosystem or ecosystems (sea, forest, desert, marshland, etc.); in other words "has their secret spot"	
15.	favours natural environment to cultivated environment	
16.	repeatedly visits some particular natural environments (has favourite places and likes talking about them)	
17.	prefers going to the Zoo to going to theme parks	
18.	learns to draw or photograph nature and products of nature because he/she has the desire to capture in picture what he/she observes in nature	
19.	is an ardent reader of or listener to books about nature animals, outdoor camping etc.	
20.	engages recreationally in outdoor, non-competitive activities (e.g. hiking, climbing, fishing, canoeing, sailing, cross-country skiing, outdoor camping, diving)	

An indicative evaluation of the test:

Less than 50 points ….. low science talent
50–75 points ……science talent combined with other talents
75–90 points……clear science talent
more than 90 points……strong science talent

If the teacher identifies a child with high level of naturalist intelligence in their class, they should inform the parents and start to develop this talent intentionally.