CHANGES IN COGNITIVE CURIOSITY AND TECHNOLOGY ACCEPTANCE IN TEACHING MATHEMATICS AFTER TRAINING IN THE GEOGEBRA SOFTWARE

Cognitive curiosity and acceptance of technology in teaching are the key factors for introducing the problem method in teaching mathematics. The current study monitored changes in cognitive curiosity and technology acceptance in 32 mathematics teachers who applied for an e-learning training on the use of the GeoGebra software. The trainings were conducted using the ROSE method. An increase in the average level of cognitive curiosity, increase in the sense of competence in using GeoGebra and a more general acceptance of technology by participants of the course was observed. Increase in cognitive curiosity seemed to be relatively independent of the increase in technical skills in using the software. The article discusses possible explanations of these results.

Keywords: cognitive curiosity, non-formal education, teaching of mathematics, perceived usefulness of technology, professional teachers development

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Cognitive curiosity is a motivational process that describes the tendency to engage in solving intellectual problems. In the literature it appears under different terms. It is referred to as the need to know, cognitive motivation, epistemic curiosity or cognitive internal motivation. Some researchers propose to use a common label of “intellectual investments”, personality mechanisms that regulate individual differences in terms of when, how and where people engage in cognitive tasks (von Stumm and Ackerman 2013).

Cognitive curiosity is a personality variable that describes preferences and not abilities. A positive correlation between intelligence and cognitive curiosity exists, but it is moderate. Meta-analysis of research indicates that on average cognitive curiosity shares about 10% of variance with cognitive efficiency measured by intelligence tests (von Stumm and Ackerman 2013). There are also associations of cognitive curiosity with openness to experience and conscientiousness (von Stumm, Hell and Chamorro-Premuzic, 2011).

Cognitive curiosity in many studies is treated as a relatively permanent personal trait, independent of situational factors. For example, studies indicate a high level of temporal stability of this variable when measured at two-week intervals (Matusz et al. 2011). It is less frequently asked what factors can lead to changes in cognitive motivation. However, this is an important issue when we take into account that cognitive curiosity, along with conscientiousness and intelligence, is one of the best predictors of academic achievements (von Stumm, Hell and Chamorro-Premuzic, 2011). At the same time, cognitive motivation seems to be a variable which is more susceptible to change than both conscientiousness and cognitive abilities. Understanding the conditions in which there is a temporary or stable change in the field of cognitive curiosity is necessary to fully understand the functions of this phenomenon, its mechanisms and neurobiological background (Kidd and Hayden, 2015).

The role of cognitive curiosity in education grows with the rate of changes that this field undergoes in recent years. Rapid changes in educational technologies, popularization of mass, network and virtual education tools, require constant development and increasing competences on the part of both teachers and students. At the same time, there is a significant difference between the field of technological innovation and education in schools In the first one innovation is strongly rewarded by the market, while in the latter, which is much wider and covers a large part of the population, with complex social relations, there is often a strong inertia of the system. In education introduction of novel technology is only the first step and success mainly requires acceptance of the changes by students, administration, parents and many other stakeholders. According to the Regulatory Theory of Social Influence (Nowak et al., 2017) one can predict that the basic element of an effective social change is the inclusion of individuals into a cooperative network that will maintain the new way of interacting and counteract the inertia pressure of the majority. Therefore, in addition to an increase in strictly technical competences, it is important to strengthen the attitudes of the participants to maintain their activity and inclusion in a new system of interaction, in a way to actually bring about social change in the teaching system.

In the case of teaching mathematics, the ability to present issues through various representations (graphical, numerical and spatial) and to illustrate dynamic changes in complex...
mathematical processes becomes more and more important. One of the tools that makes this is possible is GeoGebra – education software which was created in 2002. Currently, GeoGebra is available in different versions for most operating systems and is packaged with social media content and tools for creating online teaching materials. GeoGebra is supported by a large international community and has numerous language versions and a thousand-strong database of educational materials. GeoGebra was introduced in Poland in 2008, and the Warsaw GeoGebra Center at the SWPS University is the main place for developing materials in Poland.

However, learning GeoGebra requires strong learning activity on part of teachers and this needs to be a continuous process. In case of GeoGebra new versions of the software are constantly being introduced, which differ in functionality and require a constant follow-up of this process. Teachers cannot receive a simple script that improves their current teaching methods, but a complex tool that enables cognitive investments that pay off with new methods and a different didactic perspective. Cognitive curiosity seems to be a key element supporting this self-learning process.

In the current study, we asked a question about whether participation in the e-learning course devoted to learning the GeoGebra software leads to an increase in the acceptance of this tool as a useful didactic aid, as well as to the increase in the global level of cognitive curiosity. We assumed that the increase in competence in the use of a software requiring the activity of resolving abstract cognitive problems will lead to the global growth of self-identification as a person characterized by cognitive curiosity. Therefore, a person who takes pleasure in solving complex problems, chooses such problems for themselves and searches for new solutions, even if he already has satisfactory answers.

CURRENT RESEARCH

Participants. 32 teachers of mathematics participated in the study. The average period of their work as teachers was 20.7 years (min = 5, max = 40). The study participants recruited themselves for the study, looking for a training offer on the market and enrolling in an e-learning course. When signing up for the course, they received an optional invitation to participate in the study.

Test conditions. The study was conducted during GeoGebra courses conducted using the ROSE method (Nowak et al., 2017). Courses are organized by the AKCES Foundation. GeoGebra courses have been conducted in this form since 2010. Participants have a choice of nine course levels that are constantly adapted to new software versions. The courses are divided into several levels of difficulty: beginner, intermediate, specialist for the school level (for primary schools, grades 4-6, classes 7-8 and for upper secondary school teachers), 3D graphics view in GeoGebra, Animations and presentations in GeoGebra, Discovering theorems and regularity and an advanced course.

Courses are divided into modules and last about 10 weeks, during which the participants prepare several applets. These tasks are then evaluated by trainers on the e-learning platform. The aim of the courses is to acquire practical knowledge and skills in the field of GeoGebra, as well as to prepare applets that the teacher can use during the lesson. Tasks can be performed at any time within a week. The courses are prepared and run by teachers of practitioners who use GeoGebra on their daily basis in their lessons, they are also trainers and experts of the Warsaw GeoGebra Center.

In the current study, a repeated measurement was made at the beginning of the GeoGebra course (October 2017) and at the end of the course (December 2017). In each
measurement participants were presented with a set of questionnaires to fill in online.

Need of Cognition Questionnaire. The Polish version of the need for cognition questionnaire was used (Matusz, Traczyk and Gąsiorowska, 2011). The questionnaire consists of 36 statements describing behaviors related to cognitive curiosity. Answers are given on a five-point scale from “strongly disagree” to “strongly agree”. The participants of the study answered questions via an online form. The same questions were asked twice, but they were presented in time in a random order.

Technology Acceptance Questionnaire. The scale of perceived usefulness of the GeoGebra software was based on the basic assumptions of the technology acceptance model (Venkatesh et al., 2003, Słomka et al., 2007). This model assumes that the actual use of technology is the resultant of its perceived utility (eg “When using GG I have more control over the tasks performed”), ease of use (eg “Learning how to use GG is easy”), intentions of use (eg “I will he used GG regularly in the future”) and the general attitude towards a given product (eg “I would rather not replace GG with another software “). The questionnaire consists of 16 statements which are answered on a five-point scale from “Definitely not” to “Definitely yes”. Cronbach Alpha ratio for the questionnaire was 0.90 for the first and 0.91 for the second measurement. The same questions were asked twice, but they were presented during each filling in a random order.

Additional questions. Participants of the study were also asked about their professional experience, form of employment, how long they used the GeoGebra software, how often they use it during the lesson, how well do they know the software and what is their motivation to learn it.

RESULTS

32 teachers took part in the study, 5 of whom (16%) taught in primary school, 1 (3%) in junior high school, 25 (78%) in upper secondary school and 1 (3%) in higher education. The majority of the group consisted of qualified teachers (26 people, 81%), 3 persons were contract teachers and 3 persons were appointed teachers.

Most of the group took part in a course at the basic level (16 people, 50%), 11 people chose an intermediate course (34%), and 5 people (16%) chose a course targeted at the selected level of education. Half of the group were new users who at the beginning of the course estimated their level of competence in using the software on average at 1.19 (SD = 0.4) on a scale of 1 to 5. The participants of the intermediate-level course estimated their competences at 2.36 (SD = 0.8), and oriented courses at the level of 2.6 (SD = 0.5). During the second measurement the sense of user competence significantly increased, on average by 1.34, t (31) = 8.11, p < 0.001 and amounted to basic courses M = 2.8 (SD = 0.8), for intermediate courses M = 3.5 (SD = 0.5), and for targeted courses M = 3.2 (SD = 0.4).

Cognitive curiosity at the first measurement was 2.83 on average (SD = 0.27, correlation between measurements was, r (32) = 0.59) on a scale from 0 to 4, and during the second measurement it increased on average by 0.14 to value of 2.97 (SD = 0.36). This a statistically significant difference, t (31) = 2.64, p < 0.05, with Cohen’s effect strength: 0.489. The level of technology acceptance during the first measurement was on average 2.83 on average (SD = 0.27, correlation between measurements was, r (32) = 0.59) on a scale from 0 to 4, and during the second measurement it increased on average by 0.32 to value of 3.08 (0.52). It is a statistically significant difference, t (31) = 3.26, p < 0.01, and Cohen’s d effect: 0.571.
It was expected that the increase in the level of competence and technology acceptance would co-occur with the increase of cognitive curiosity. It turned out, however, that although increase in the sense of competence in using the GeoGebra software coincides with the increase in the level of technology acceptance, \( r (32) = 0.43, p < 0.01 \), there is no significant correlation of cognitive curiosity increase and increase in competence level, \( r (32) = 0.14, p \text{ ns} \), or cognitive curiosity and technology acceptance, \( r (32) = 0.14, p \text{ ns} \).

It was not shown that the length of the teacher’s work experience is related to individual differences (or changes in the level of variables between measurements) in terms of cognitive curiosity: in measurement 1, \( r (32) = -0.16, p \text{ n.s.} \). In measurement 2, \( r (32) = -0.15, p \text{ n.s.} \). on acceptance of these technologies: in measurement 1, \( r (32) = -0.15, p \text{ ns.} \). in measurement 2, \( r (32) = -0.26, p \text{ ns.} \).

However, a negative correlation was found between length of work experience and the perception of change in competences in using the GeoGebra software, \( r (32) = -0.43, p < 0.01 \). The longer the work experience, the less sense of competence increase.

When analyzing the results of Pearson’s correlation tests, it should be noted that for a sample of this size and significance level set at \( p < 0.05 \), the 80% power of the test is achieved for correlations at minimum of about 0.5. It should, therefore, be considered that the study was only able to detect strong correlative relationships between correlated variables. Any weaker relationships must be determined in subsequent studies using a larger sample. In contrast, with the t-test with repeated measures, a 80% power is obtained for effects in the Cohen \( d = 0.5 \) region, which could be described as moderate (not large) in size.

### DISCUSSION

Hypothesis about the increase of cognitive curiosity and increase in the acceptance of technology in teaching during the course of training in the GeoGebra software was confirmed. However, it should be noted that the increase in these variables seems to be independent of each other. While the increase in the sense of competence in using the GeoGebra software translates into an increase

#### Table 1. Descriptive statistics

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Min</th>
<th>Max</th>
<th>M</th>
<th>SD</th>
<th>Skośność</th>
<th>Kurtóza</th>
</tr>
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<tbody>
<tr>
<td>Knowledge of GeoGebra's operation (beginning of the course)</td>
<td>32</td>
<td>1</td>
<td>4</td>
<td>1.81</td>
<td>.86</td>
<td>.71</td>
<td>.37</td>
</tr>
<tr>
<td>Knowledge of GeoGebra support (end of the course)</td>
<td>32</td>
<td>1</td>
<td>4</td>
<td>3.16</td>
<td>.72</td>
<td>-.79</td>
<td>1.27</td>
</tr>
<tr>
<td>Cognitive curiosity (beginning of the course)</td>
<td>32</td>
<td>2.36</td>
<td>3.33</td>
<td>2.83</td>
<td>.27</td>
<td>-.17</td>
<td>-.77</td>
</tr>
<tr>
<td>Cognitive curiosity (end of the course)</td>
<td>32</td>
<td>2.42</td>
<td>3.89</td>
<td>2.97</td>
<td>.36</td>
<td>.36</td>
<td>.36</td>
</tr>
<tr>
<td>Technology acceptance (beginning of the course)</td>
<td>32</td>
<td>1.56</td>
<td>3.56</td>
<td>2.76</td>
<td>.53</td>
<td>-.39</td>
<td>-65</td>
</tr>
<tr>
<td>Acceptance of technology usability (end of the course)</td>
<td>32</td>
<td>1.75</td>
<td>3.94</td>
<td>3.08</td>
<td>.52</td>
<td>-.77</td>
<td>65</td>
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in acceptance of the use of this software in didactics, increases the intentions of its use in the future and a sense of its usefulness, there is no proof that this would translate into changes in cognitive curiosity.

Increases in cognitive curiosity have occurred regardless of the teacher’s work experience and it is worth noting that the work experience of teachers participating in the training was varied, but on average quite high (about 20 years). Despite this, a significant change in the level of cognitive curiosity can be seen in two measurements made over a period of about 8 weeks. There are several possible interpretations of such an increase:

a) participation in the course could be a pleasant experience, which changed the self-perception of teachers and their questionnaire responses during the second assessment. It can be assumed that on the basis of accessibility heuristics - the feeling that you are a person who is someone who is often involved in solving complex cognitive problems and likes to broaden their knowledge has increased. In order to verify this interpretation, additional post-tests should be carried out, which would check the stability of the change in terms of cognitive curiosity and would measure it outside of the context of the course itself. However, it should be noted that during the first measurement, the participants of the study were already in the initial stages of the course, thus they filled in the self-description during both measurements in a similar context.

b) it is possible that the participants of the study tried to guess the intentions of the experimenters and tried to present themselves in the self-description as persons who are characterized by high cognitive curiosity. This interpretation is not likely as such self-presentation would be equally probable during the first measurement (when participants present their intentions) and the second measurement (when they might have wanted to express a sense of success), so it would affect the general level of this variable, and not the level of change.

c) it is possible that the participants of the study actually experienced some changes in the field of cognitive motivation. It should be noted that the majority of users were taking either the course for beginners or intermediate users. We know that curiosity - in contrast to other types of motivation - increases with the frequency of its satisfaction. If we treat curiosity as the state of cognitive deprivation associated with the perception of lack of knowledge or understanding of a topic (Loewenstein, 1994), it can be expected that the transition from a relative novice to the level of a more experienced user would primarily involve the identification of areas of ignorance. The perception of their own ignorance, combined with the basic sense of competence in a given area, will lead to curiosity and activity aimed at filling gaps in knowledge and understanding. The obtained data does not allow for unambiguous statement whether we are dealing with the actual increase of cognitive curiosity or with a temporary change in the scope of applying for yourself using the availability heuristics. The answer to this question must be brought by further longitudinal tests, containing a larger number of measurements.

The limitations of the current study include, above all, the lack of a control group and a homogeneous, self-descriptive character of measurements. In the future, one should consider going beyond these limitations and using a control group that would participate in training on non-strictly cognitive competences. The method of measuring cognitive curiosity to a wider extent than the self-description could be to monitor the interests and activity of study participants in a wider time perspective. Changes in the field of cognitive curiosity should be visible, for example, in the changes in the way of spending free time, which can be
monitored through activity on social networking sites (Therriault et al., 2015).

In summary, the current study shows a potential method of introducing changes in cognitive curiosity by involving people in solving complex cognitive problems related to their area of professional activity. The increased sense of competence in the use of the GeoGebra software translated into an increase in acceptance of the use of these technologies in teaching and a sense of their usability. The level of increase in the sense of competence was dependent on work experience of the teacher, the more experienced teachers were more modest in the perception of increase of their competences. On the other hand the increase in cognitive curiosity seems to be independent of both seniority and the level of acceptance of the use of technology in teaching. We hope that further research in this area will bring answers to the questions that have now been marked.

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ZMIANY CIEKAWOŚCI POZNAWCZEJ I AKCEPTACJI TECHNOLOGII W NAUCZANIU MATEMATYKI PO SZKOLENIU W PROGRAMIE GEOGEBRA

STRESZCZENIE

Ciekawość poznaowcza i akceptacja technologii w nauczaniu to kluczowe czynniki umożliwiające wprowadzanie metody problemowej w nauczaniu matematyki. W obecnym badaniu monitorowano zmiany w zakresie ciekawości poznaowczej i akceptacji technologii u 32 nauczycieli matematyki, którzy zgłosili się na szkolenie e-learningowe dotyczące obsługi programu GeoGebra. Szkolenia prowadzone były metodą ROSE. Zaobserwowano wzrost średniego poziomu ciekawości poznaowczej, poczucia kompetencji w zakresie obsługi programu i akceptacji technologii u uczestników kursu. Wzrost ciekawości poznaowczej nie był jedynie wynikiem wzrostu zdolności technicznych w zakresie obsługi programu. W artykule dyskutowane są możliwe wyjaśnienia tych wyników.

Słowa kluczowe: ciekawość poznaowcza, edukacja nieformalna, nauczanie matematyki, postrzegana użyteczność technologii
ATTACHMENT 1

Technology Acceptance Scale – GeoGebra (GG) Software

1. It is more pleasant to do my job when I use GG
2. When I use GG I have more control over the tasks being performed
3. Using GG allows me to finish tasks faster
4. GG increases the efficiency of my work
5. Overall, GG is useful in my work
6. GG is uncomfortable to use
7. Learning to use GG is easy
8. Setting different options in GG is frustrating
9. It's easy to find everything I need to work on the GG menu
10. Generally, using GG is easy
11. The idea to use GG in class is tragic
12. It's good that I came across GG
13. I probably will not replace GG with another software
14. I definitely recommend GG to other users
15. I will use GG regularly in the future
16. I will often use GG