UNIVERSITY OF SZEGED
FACULTY OF ARTS
DOCTORAL SCHOOL OF EDUCATION

TEACHING AND LEARNING

ATTILA PÁSZTOR

TECHNOLOGY-BASED ASSESSMENT AND DEVELOPMENT OF INDUCTIVE REASONING

Summary of the PhD dissertation

Supervisor:

Prof. Dr. Benő Csapó

Szeged

2016

SUBJECT AND STUCTURE OF THE DISSERTATION

In the 21st century the significance of competencies is increasing in our everyday life and in the labour market as well (Kozma, 2009). Such complex competencies like creativity, learning to learn, cooperation or ICT literacy (Binkley, Erstad, Herman, Raizen, Martin, Miller-Ricci & Rumble, 2012) were identified and described for example in the ACT21s project (Assessment & Teaching of 21st Century Skills). However, a sufficient level of general thinking skills is necessary in order to operate and develop these competencies. Both international (PISA, TIMMS, PIRLS) and national assessments showed that there are many problems with the quality of knowledge of Hungarian pupils (Csapó, 1998a; 2004a; 2012; Csapó, Fejes, Kinyó, & Tóth, 2014). Students have to deal with increasing amount of subject material but the acquired knowledge is often fragmented, the level of understanding is low, therefore the application and transfer of this knowledge in wider context is fairly limited. Researches showed this phenomenon in many domains such as in the development of scientific concepts (Korom, 1998), in understanding of mathematics (Dobi, 1998) or in the application of scientific knowledge (B. Németh, 1998). This line of thought also highlights the significant role of thinking skills as one of the reasons behind these phenomena could be the insufficient level of general cognitive abilities. However, research data shows that teaching in schools hardly effects the development of thinking skills (Csapó, 2004b).

Many educational experts are arguing for the increasing need of measuring and developing thinking skills in everyday school context (Adey, Csapó, Demetriou, Hautamaki, & Shayer, 2007; Resnick, 1987). Especially in early school years since the low level of cognitive abilities may lead to difficulties in understanding of subject materials, therefore efficient early interventions could significantly return in later school years (Nagy, 2008). However, without the lack of knowledge about the nature, structure, development and modifiability of different abilities and without the lack of easy to use instruments available for everyday application in educational practice to assess and foster thinking skills, the design and implementation of efficient interventions are hard to realize.

One of the major difficulties in classroom teaching comes from the large variance of students in terms of their abilities. Thus, applying methods which can efficiently handle these individual differences is challenging. In order to address this challenge there are many problems to be solved. From the assessment perspective frequent diagnostic assessment is necessary to obtain a detailed picture of students' skills, to monitor their development and to evaluate the efficiency of interventions on empirical basis. In addition, we need training programs which can handle the individual differences, interventions where the training effects are fitting the actual needs of students' cognitive level.

Technology-based assessment and development may provide feasible solutions to address the above mentioned problems and challenges. One of the main aims of the dissertation is to demonstrate the potential of technology-based assessment and technology-based development in classroom context. We also provide empirical basis for further implementations of efficient online assessment and development of thinking skills in general, more specifically for inductive reasoning. Our research also contributes to gain a more detailed picture of the targeted construct, namely inductive reasoning. In order to fulfil these aims we carried out online assessments of inductive reasoning in kindergarten and among first and fourth grade students. Besides the measurements we also carried out a digital game-based developmental training program to foster third and fourth grade students' inductive reasoning.

In the theoretical chapters we discussed the philosophical aspects of induction, described inductive reasoning with respect to different psychological paradigms, we showed the role of inductive reasoning in various cognitive processes and we also presented its measurement and its development in relation with background variables in educational context (Chapter 1). Next we explored different approaches of fostering thinking skills in general. Our developmental program is based on Karl Josef Klauer researches so we described his view on inductive reasoning and his work on enhancing the skill in more detail (Chapter 2). We also explored the possibilities and limitations of technology-based assessment in general and more specifically with respect to inductive reasoning in educational settings (Chapter 3). After assessment perspective we shifted our focus to the developmental aspects: we discussed the possibilities, limitations and challenges of digital game-based learning (DGBL) in school context (Chapter 4). Further chapters described our empirical researches. After presenting the aims, research questions (Chapter 5), we described our methods and reported our results (Chapter 6), followed by the methods and results of our training program (Chapter 7). The dissertation has ended with a general discussion on the results of the assessments and of the training program (Chapter 8).

THEORETICAL BACKGROUND

Based on observed phenomena and our current knowledge induction makes us able to inference to the unobserved, formulating novel conclusions about the unknown and generate new knowledge (Hempel, 1998; Sloman & Lagnado, 2005). We argued that it is difficult to provide a unified view of induction. We can understand its nature and processes with respect to different philosophical or psychological traditions such as psychometrics, Piaget's school and cognitive psychology. What is common in the different approaches is that all of them state that induction is one of our fundamental thinking processes and it plays a central role in human cognition, knowledge acquisition and in the transfer of knowledge. Therefore the educational relevance of the skill is well grounded. From educational perspective we considered Klauer's and his colleagues view of inductive reasoning as one of the well-structured and detailed theory and system (Klauer, 1989, 1990; 1996; 1997; Klauer & Phye, 1994; Klauer, Willmes, & Phye, 2002). Our developmental training is based on this approach and our assessment items also can be understood in this framework. According to Klauer "inductive reasoning consists of detecting regularities and irregularities by finding out

A: {a1: similarity; a2: difference; a3: similarity and difference}
of
B: {b1: attributes; b2: relations}
with
C: {c1: verbal; c2: pictorial; c3: geometrical; c4: numerical; c5: other}
material" (Klauer & Phye, 2008, p. 87).

With the combination of the facets one can formulate 30 cases (3x2x5). The central part of the definition is the facets of A and B. The Cartesian product of these two sets leads to six process of inductive reasoning (Table 1). Furthermore, the model also describes the relationships among these processes (Figure 1). The precise definition and its structure of Klauer's view on inductive reason makes it as a solid basis for assessments and developmental purposes as well in educational settings.

Recognizing its important numerous domestic researches focused on inductive reasoning including its assessment, its structure and its relation to other constructs and background variables in educational context (Csapó, 1994; 1997; 1998b; 2001a; 2003a; 2003b; Csapó & Molnár, 2012; Csapó & Molnár, 2013; Csapó, Molnár, & Kinyó, 2009; Molnár, 2008a; Molnár & Csapó, 2011; Nagy L.-né, 2006; 2013; Tóth, Csapó, & Székely, 2010). The results confirmed the significance of inductive reasoning in human cognition. Measurements on different samples showed the fast development of the skill in the early years of schooling, thus, interventions should be implemented in this period. Findings also underpin the phenomenon that the different forms of inductive reasoning are strongly connected and the most significant component was the analogical reasoning. The strongest correlations were found between tests measuring application of knowledge in science, mathematical understanding and foreign language. Medium correlations were found with grades but these connections showed weakening tendency by the end of public education. The relationship between inductive reasoning and subject attitudes were weak, there were considerable correlations only with the subjects of mathematics, history and Hungarian grammar. There were no significant differences between genders but achievements are strongly influenced by parents' education and pupils' socioeconomic background in general. Studies also revealed large differences between schools and classes.

Table 1
Types of inductive reasoning problems (Klauer & Phye, 2008, p. 88).

Process	*Facet identification*	*Cognitive operation required*	*Item formats*
Generalisation	a_1b_1	Similarity of attributes	Class formation Class expansion Finding common attributes
Discrimination	a_2b_2	Discrimination of attributes (concept differentiation)	Identifying disturbing items
Cross classification	a_3b_1	Similarity and difference in attributes	4-fold scheme 6-fold scheme 9-fold scheme
Recognizing relationships	a_1b_2	Similarity of relationships	Series completion Ordered series Analogy
Differentiating relationships	a_2b_2	Differences in relationships	Disturbed series
System construction	a_3b_2	Similarity and difference in relationships	Matrices

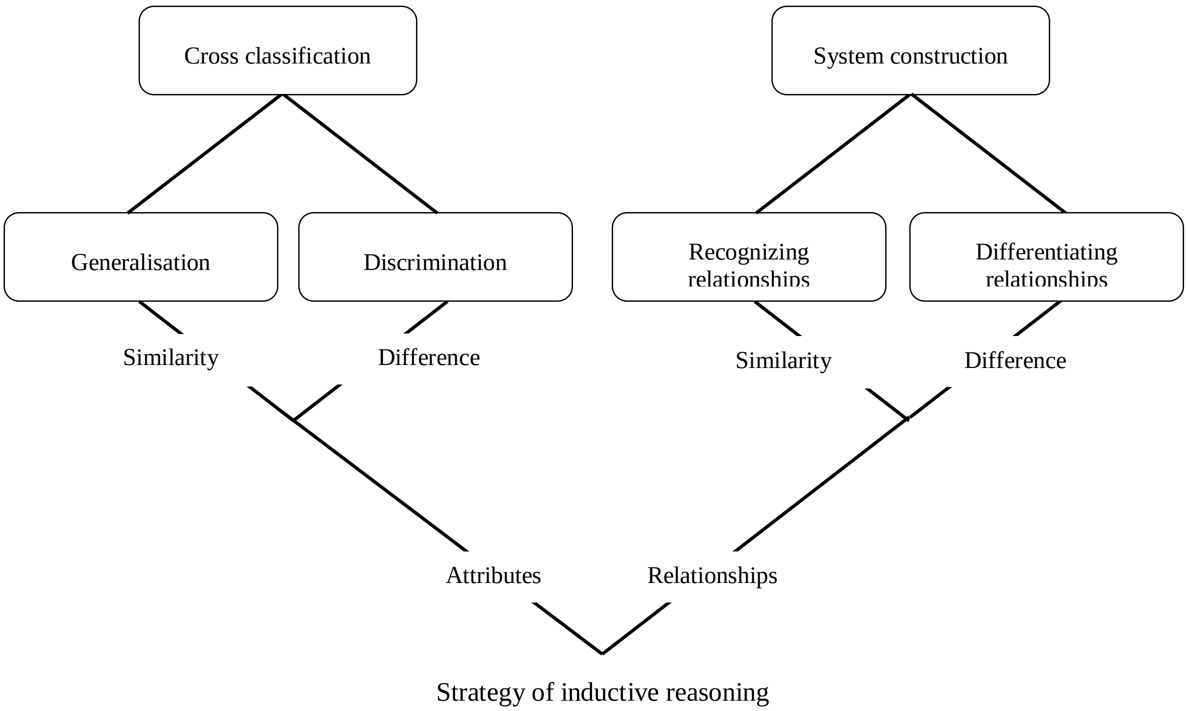

Fig. 1 Genealogy of tasks in inductive reasoning (Klauer & Phye, 2008, p. 89.).

Regarding fostering thinking skills we discussed the attributes of teaching thinking directly and with content based methods integrating school curricula in the developmental activities (“infusion” or “embedding approaches”) (Csapó, 1999). We argued that both approaches have its own advantages and in order to maximize the learning effects one should apply both attributes in the design and implantation of interventions. We described Klauer’s developmental programs and the findings of the experiments in more detail. The effectiveness of these trainings has been demonstrated in numerous studies in different contexts such as in various cultures, ages, in different target groups (students with special need, average or gifted students), or in different settings (training individually, in pairs or in class) (Barkl, Porter, & Ginns, 2012; de Koning & Hamers, 1999; de Koning, Hamers, Sijtsma, & Vermeer, 2002; Hamers, de Koning, & Sijtsma, 1998; Klauer, 1996; Klauer & Phye, 2008; Klauer, Willmes, & Phye 2002; Tomic, 1995; Tomic & Kingma, 1998; Tomic & Klauer, 1996).

In the chapter dealing with technology-based assessment we argued that it has many advantages from data collection and management to evaluation and application of test results compare to traditional paper-based or face-to-face assessments methods (Csapó, Molnár, Pap-Szigeti, & R. Tóth, 2009; Csapó, Molnár, & R. Tóth, 2008; Molnár, 2010; 2011; Pásztor-Kovács, Magyar, Hülber, Pásztor, & Tongori, 2013). Delivering tests with technology can significantly reduce the time and costs of the testing process. Applying automatic scoring and evaluation we can provide immediate feedback which contributes to the improvement of the effectiveness of feedback mechanism in all level of public education. With the advantages of technology-based assessment the quality of the data can be increased, we can execute individual testing (e.g. adaptive testing) and it opens the ways of designing innovative items in order to assess constructs which could not be possible with traditional methods (Magyar, Pásztor, Pásztor-Kovács, Pluhár, & Molnár 2015). All of these features contributing to the implementation of more efficiently large scale assessment and the possibility of testing young students (e.g. pre-recorded instructions, interactive items). As a result we can provide easy to use assessment instruments for teachers and with these easy to use tools they can improve the quality of their teaching (e.g. fitting their teaching methods for the actual level of students’ knowledge and skills). In spite of the limitations of technology-based assessment (e.g. high costs of the development of a system in the initial period, technical conditions in schools, media effects) educational experts are arguing that technology-based assessment will replace the traditional assessment methods (Csapó et al., 2008, 2009; Kozma, 2009; Molnár, 2011).

Regarding technology-based development we discussed the challenges and possibilities of digital game-based learning. Applying digital games in education is a rapidly developing research field, however there are many questions still unanswered and there are still a lot of potential unexploited (Pásztor, 2013). Many of the advantages are in parallel with the possibilities of technology-based assessment such as automatic scoring, immediate feedback and innovative item design. One of the closest relations can be identified through the term of formative assessment (Csapó, Lőrincz, & Molnár, 2012). One of the promising fields of digital game-based learning is the development of thinking skills (Pásztor, 2014). Learning tasks with interaction and manipulation, providing optimal challenge for students (see Vygotsky’s concept of zone of proximal development), possibilities for different learning tracks and playful learning environments for increasing motivation are all such features which can be considered in the design of digital teaching games. However, meta analyses are showed that applying efficiently of these attributes in a digital game is not an easy endeavour (Young, Slota, Cutter, Jalette, Mullin, Lai, Simeoni, Tran, & Yukhymenko, 2012; Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013; Wouters & Van Oostendorp, 2013). Numerous recent researches on the field focus on the specific conditions of how to develop efficient learning games in terms of motivation and learning, for instance to find the optimal balance of game elements and learning material. In spite of the growing international interest there are lack of researches addressing these issues (see Csapó et al., 2012; Debreczeni, 2014; Molnár, 2011a, 2011b; Pásztor, 2013; 2014).

RELEVANCE AND AIMS OF THE RESARCH

In order to efficiently foster inductive reasoning in classroom context and to monitor students' development reliable and valid easy to use assessment instruments are have to be available for the teachers. In Hungarian context Csapó's test (1994) is suitable for this aim if our target group is between grade three and eleven (10 to 17 years). The test comprises number series and analogies and word analogies. Therefore to complete this test basic numerical and reading skills are necessary so it cannot be applied in earlier ages. Molnár (2006, 2008a, 2011a) developed a test using figurative items for first and second grade students but this test cannot be administered in upper grades due to the ceiling effect.

Test development in our research is basically a continuation of the above mentioned test developmental processes. The research gap here is that there are no tests available which are using figurative items and can cover the whole range of early years of schooling. The other research line is the application of the advantages of technology-based assessment. In the theoretical chapters we argued that with manipulative items and with pre-recorded instructions the validity and objectivity of the tests can be increased especially in younger ages. In addition, with computerized data collection, automatic scoring and with immediate feedback the tests become easy to use for teachers in classroom context. Therefore our aim was to develop new easy to use online tests which are using figurative itemes and suitable for assessing inductive reasoning in the early years of schooling.

Above test development we also aimed to explore the possibilities of digital game based learning. In order to fulfil this goal we developed a playful online training program fostering third and fourth grade students' inductive reasoning. This research is based on Klauer's (1990) program and Molnár's (2006, 2008b, 2011a, 2011b) experiments adopting Klauer training concept and also strongly related to our common researches with Molnár (Molnár & Pásztor, 2012, Molnár et al, 2012; Pásztor & Molnár, 2012; Pásztor & Rausch, 2013). In contrast to previous researches in our training program instead of general content we used mathematical material. In this regard we are shifted in the direction of content based methods. Our experiment could be considered as a first step in a long research process. The primary aim was to examine the effectiveness of our online learning tasks using immediate feedback supplemented with instructional support.

The developmental experiment was conducted before our large scale assessments so we used a different but also own developed test to measure the training effects. In fact, this test development could be viewed as the first step of the item development for the large scale assessments. Based on this test we developed the fourth grade test followed by the tests for the first grade and kindergarten students. In Table 2 we summarized the timeline of our research connected to the dissertation.

Table 2
The timeline of our research

Timeline	Research activities
September 2013	Pilot test for the developmental experiment
November – December 2013	Carrying out the developmental experiment
March – June 2014	Pilot test for the fourth grade test
November 2014	Large scale assessment in grade four
May and September 2015	Pilot test for the first grade test
October 2015	Large scale assessment in grade one
November 2015	Pilot test for the kindergarten test
February – April 2016	Assessment in the kindergartens

RESEARCH QUESTIONS, HYPOTHESES

Research questions and hypotheses can be divided in accordance with the two major parts of our research: the assessments and the developmental experiments.

I. *Research questions in relation to the psychometric properties of the tests and the structure of inductive reasoning (H_1-H_4):* Are the psychometric properties of the tests acceptable? Could be the sub-constructs distinguished on empirical basis (construct validity)? How are the sub-constructs related to each other? What is playing a more significant role in the mechanism of inductive reasoning: content (e.g. numerical or figural) or operations (e.g. series or analogies)?

Hypotheses:

H_1: The psychometric properties of the tests are acceptable

H_2: We expected medium correlations between the sub-constructs.

H_3: Based on previous research data we hypothesized that both content and operations play significant role in the mechanism of inductive reasoning.

H_4: Construct validity could be examined with confirmatory factor analyses (CFA). On the basis of previous studies we expect the best model fits for models where every sub-tests represent one sub-constructs.

II. *Research questions in relation to the development of inductive reasoning and its relation to background variables (H_5-H_{14}):* Is there significant differences in the achievements within the age cohorts? How to develop inductive reasoning between the age cohorts? Do the skills how to use the computer mouse effect the achievements of inductive reasoning in the first grade and kindergarten children? What are the relations of the achievements with background variables?

Hypotheses:

H_5: We hypothesized significant achievement differences in first grade and kindergarten students within the samples.

H_6: We hypothesized no significant achievement differences within the fourth grade sample.

H_7: We expected that inductive reasoning develops to a great extent from kindergarten to fourth grade.

H_8: We hypothesized that computer mouse use skills have no effects on the achievements of inductive reasoning. Children have the necessary mouse usage skills to complete the tests.

H_9: On the basis of previous research data we hypothesized that strong selection mechanism can be identified between kindergarten and first grade.

H_{10}: We also expect large achievement differences between schools and classes.

H_{11}: In accordance with previous findings we expect no significant differences between genders.

H_{12}: In line with previous researches we hypothesized that parents' level of education significantly effects the achievements.

H_{13}: On the basis of prior findings we expect medium correlations between inductive reasoning achievements and grades.

H_{14}: Based on the literature we expect weak correlations between inductive reasoning and attitudes toward subject and students' statements about the importance of being good at the subjects.

III. *Research questions in relation to the possibilities of fostering inductive reasoning (H_{15}-H_{16}):* Could be the development of inductive reasoning enhanced with the application of the advantages of digital game-based learning in three and fourth grade students? Can the

Klauer training concept be adopted to online environment using mathematical content in the learning tasks?

Hypotheses:

H_{15}: As a result of the training the experimental group significantly outperform the control group in terms of the inductive reasoning achievements.

H_{16}: Students have positive attitudes toward the training program.

ONLINE ASSESSMENT OF INDUCTIVE REASONING IN KINDERGARTEN, AMONG FIRST AND FOURTH GRADE STUDENTS - METHODS

Samples

Samples of the first and the fourth grade students were samples of the Hungarian Educational Longitudinal Program (Sample V. and VI.) (Csapó, 2014, p. 147). The fourth grade sample consisted of 5017 students, age mean was 10.26 years (SD=.49). All together 143 schools and 253 classes participated in the study. There were 6013 students in the first grade sample, age mean was 7.08 years (SD=.48), with the participation of 178 schools and 292 classes. The kindergarten research was carried out in Szeged. Kindergartens could voluntarily join to the assessments. The sample consisted of 278 children form 16 institutes, age mean was 5.56 years (SD=.69).

Development of assessment instruments, background variables

In the fourth grade test besides figurative series and analogies we also used number series and analogies in order to have the possibility to develop (as a further research) a common scale based on the results of our and Csapó's test (1994). The inductive tests for kindergarten and first grade children were part of a larger test battery for assessing different dimensions of school readiness. The battery consisted of the following constructs: computer mouse usage skills, early literacy and numeracy, students' capacity to follow teacher instructions and musical abilities. From these constructs we only used the results of the computer mouse usage skills test in order to examine the possible media effects on the achievements of inductive reasoning. For these age cohorts we developed a new item type besides figurative series and analogies using also figurative elements: classification.

In the process of test development four pilot experiments were carried out for the fourth grade test, two pilot assessment were executed for the first grade test and one pilot study was conducted in kindergarten. Figure 2 present the relations of the tests to each other and the final test system as results of the pilot studies. It can be seen that the number of the anchor items are high enough to conduct IRT analyses on the data.

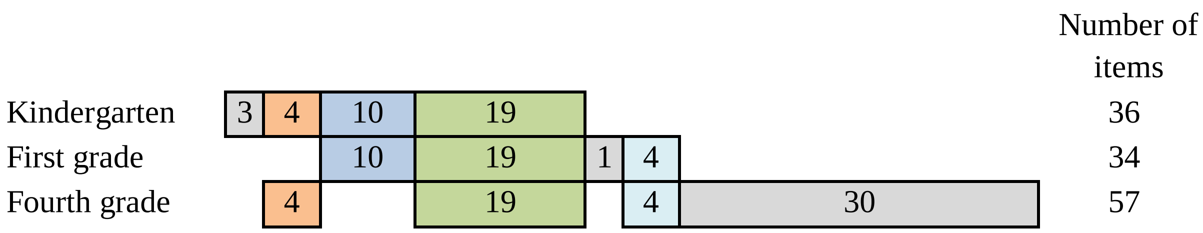

Fig. 2 Relations of the tests to each other and final test system as results of the pilot studies.

In case of the fourth grade sample we collected data for several background variables as well: gender, school, classes, parents' education, grades, attitudes toward subjects and students' statements about the importance of being good at the subjects. With regard to the first grade and the kindergarten sample we only had data for gender, institutes and classes. Before the inductive reasoning test - but within the same data session - children also completed a computer mouse usage skill test in order to let them practice basic mouse operations (e.g. clicking and drag and drop). With this design we could also examine the possible media effects. In first grade the reliability of the 10 items test was Cronbach-α=.62 (N=5996). We assumed that the few items and the celling effect (M=91.1%, SD=13.4%) are responsible for the low reliability. In addition, in previous studies we found that learning effect could occur during the test completion which also could have a negative effect on test coherency (Molnár & Pásztor, 2015). In kindergarten students completed the test on tablets. The 13 items test reliability was Cronbach-α=.72 (N=275). The achievement mean was high too: 89.2% (SD=14.3%).

Procedure, data analyses

In all age cohort data collection was carried out through the eDia (Electronic Diagnostic Assessment) system (Molnár, 2015; Molnár & Csapó, 2013). In case of the fourth and first grade the tests administered in schools' ICT rooms. Kindergarten assessments were conducted with trained test administrators in small groups using tablets. Kindergarten and first grade children could listen to the instructions via headphones. In all age cohorts instant feedback was given after test completion. After the data collection the schools could view and download the results from the eDia platform. Besides classical statistic procedures IRT (item response theory) and CFA (confirmatory factor analyses) analyses were also applied.

ONLINE ASSESSMENT OF INDUCTIVE REASONING IN KINDERGARTEN, AMONG FIRST AND FOURTH GRADE STUDENTS – RESULTS AND DISCUSSION

Regarding the test development we concluded that all assessment tools had good or acceptable psychometric properties; thus our tests are suitable measurement tools for assessing inductive reasoning from kindergarten to fourth grade students. Table 3 shows the reliabilities and basic statistics of the final test versions.

Table 3
Cronbach's alpha indices and basic statistics for the inductive reasoning tests.

Age cohort	Number of items	Cronbach-α	Mean (*SD*) %	N
Kindergarten	34	0,87	25,6 (*17,2*)	278
First grade	32	0,89	41,2 (*22,2*)	6013
Fourth grade	56	0,93	64,2(*18,9*)	5017

In all age cohort medium or high correlations were found between subtests. Empirical evidence for construct validity was provided with CFA analyses: the model fits were the best when all subtests represented different factors. In accordance with the literature (see Csapó, 1994, 1998b, 1997, 2003a; Pellegrino & Glaser, 1982; Sternberg & Gardner, 1983) our data underpin that series, analogies and classifications are all important factors of inductive reasoning. Analogies seem to be the most dominant component (Csapó, 1994, 1998b, 2003a). Regarding the content versus operation research question we found that both played a significant role in determining test achievements in respect to numbers and figures and in respect to series and analogies. In general we can conclude that our hypotheses in relation to the psychometric properties of the tests and the structure of inductive reasoning were confirmed.

We used the phrase “in general” intentionally because the psychometric analyses also showed the limitations of the usability of the tests. These limitations determine the major line of further researches as well. On the basis of means, standard deviations, distributions and IRT analyses the fourth grade test has week differential power in high skill levels. The tendency is the opposite among first grade students and kindergarten. The data indicate that the current version of the fourth grade test supposedly fits the best to third grade students and the first grade test fits the best to second grade students. One of our aims for further research is to carrying out assessment among these age cohorts as well. In addition we also need further items in kindergarten, grade one and four to cover all skill levels. However, on the basis of testing time data this possibility is fairly limited. In order to solve this problem adaptive testing (see Magyar, 2012, 2014) should be applied: the range of skill levels within one age cohort is too wide to assess with one fix test precisely. Our current data serves a good basis for this further research line.

Regarding the development of inductive reasoning we found that it develops to a great extent from kindergarten to fourth grade, our hypothesis was confirmed (H_7). However, standard deviations indicated the large individual differences within age cohorts. Our hypotheses regarding achievement differences within the age cohorts partially confirmed (H_5, H_6). There were significant differences in kindergarten but not in the first grade and we found weak but opposite and significant correlations between achievements and age in the fourth grade. As a possible reason we assumed that schools are having difficulties in helping students with low achievements. But this is only a hypothesis and should be tested as further research.

The results of mouse usage skills test showed that children had no difficulties with the completion of the inductive reasoning test. As we assumed on a sample level mouse usage skills did not distort the results and our conclusions with respect to inductive reasoning (H_8). However, deeper analyses revealed that there were some cases where the lack of mouse usage skills could be a problem. This finding supports the idea that technology-based assessments could be efficiently executed even among young children but also draw the attention to the necessity of the of the mouse usage skills test.

The most important result in connection with school and class differences was the demonstration of the strong selection effects between kindergarten and elementary schools, our hypothesis was confirmed (H_9). However, it has to be noted that only kindergartens from Szeged were participating in the study therefore further researches should be carried out to generalize this finding. In accordance with previous researches we also found large differences between schools and classes in first and fourth grade as well (H_{10}) (Csapó, 2002b, 2003b; Molnár, 2008a; Molnár & Csapó, 2011; Tóth et al, 2010). Also in accordance with previous studies no differences were found between genders (H_{11}) (e.g. Csapó, 2003a). The lack of differences also indicates that there were no media effects between genders straightening the validity of our measurements on inductive reasoning. Our hypotheses in connection with the effects of parents’ education were confirmed, too: there are large differences between students with different parents’ education (H_{12}). Our data provided further empirical evidence that reducing the differences between children with different socioeconomic background is still a problem to be solved (Csapó, 2001, 2003a). Results on grades and subjects’ attitudes and statements were also fitting to the previous tendencies (Csapó, 1997, 1998b, 2003a). Medium correlations were found between grades and inductive reasoning (H_{13}). The strongest relation could be observed with mathematics supposedly due to the nature of our items. We viewed this level of relations as a realistic picture considering the nature of the measured thinking skill and the grading practice in schools. There were no connections between subject attitudes and students' statement about the importance of being good at a subject (H14), therefore our hypotheses was confirmed. We argued that these findings are not indicators of problems since this means that regardless of the skill level students like the subjects and they think it is important to being good at them.

With the application of the advantages of technology-based assessment we demonstrated that online large scale assessments could be efficiently implemented even in young ages. Manipulative items and pre-recorded instructions assumedly improved the validity and objectivity of our assessments. Our data indicate that with online assessments we can provide immediate feedback about students' inductive reasoning for the teachers. With these easy to use online tests teachers are able to plan personalized teaching methods taking into account the individual differences on an empirical basis. In this context online assessments are contributing to the improvement of the quality of teaching. Technology-based assessments have a large impact on research practice as well since even data from large scale assessments could be easily the subject of statistical investigations. In addition, log files analyses could extend the scope of the research questions for instance we can obtain a detailed picture of the targeted construct.

EXAMINE THE EFFECTIVNESS OF AN ONLINE INDUCTIVE REASONING TRAINING PROGRAM - METHOTDS

Sample

All together 314 students were involved in the study with the participation of 147 third and 167 fourth grade pupils (age mean=9.72, SD=.67). The experimental group consisted of 88 students while the others constituted the control group (N=226).

Description of the training

The training program was based on Klauer's model of inductive reasoning and on his concept of Cognitive training for children (Klauer, 1989). The instrument consisted of 120 computerized learning tasks, separated into 20 tasks for each operation. Instead of general content we embedded the tasks with various mathematical contents (e.g. recognizing and discriminating relations or attributes through mathematical operations, number series or units of measurements). Attributes of digital games-based learning were applied in order to enhance the learning effects. Students could manipulate within the items: answers had to be given by clicking and drag and drop functions. Pupils received immediate feedback after every learning task and in case of failure, instructional support was provided in order to guide the learning process. In groups of 20, students participated in a 5 weeks long training taking place in the school's ICT room during the afternoons after regular teaching. Pupils logged in to the system and played alone. Only two coordinators were in the ICT room in order to handle technical problems and carrying out the administration of the training.

As we mentioned before we did not have the test yet which was used in the large scale assessments. We developed an inductive reasoning test based on Klauer's operations in order to measure the effectiveness of the training. The test comprised 43 figural, non-verbal items and had good reliability indices (pretest: Cronbach α=.83, posttest: Cronbach α=.86). Besides the test we administered a short questionnaire about the attitudes of the students toward the training program as well (e.g. Did you like the game?). Both the training and the assessments were carried out through the eDia platform (Electronic Diagnostic Assessment System).

EXAMINE THE EFFECTIVNESS OF AN ONLINE INDUCTIVE REASONING TRAINING PROGRAM – RESULTS AND DISCUSSION

Our aim was to investigate the effectiveness of an online playful training program which develops inductive reasoning strategies through tasks embedded into mathematical content. There was no significant difference on the pre-test scores between the two groups, while on the post-test the experimental group significantly outperformed the control group. There was no significant group difference with regards to gender and grade. The effect size of the training program was d= .33. Children reported that they enjoyed playing the game and had positive attitudes towards it. Our findings demonstrated an example of how to integrate mathematical content and reasoning strategies into a digital game-based learning environment. Our hypotheses regarding the training program were confirmed (H_{15} and H_{16}).

However, further analyses of the data revealed that not every child improved during the training and that two of the inductive strategies did not develop significantly at the group level. In addition, our effect size was not as high compare to the effect sizes in the literature (Klauer & Phye, 2008; Molnár, 2006). We can conclude that further corrections are necessary in order to improve the effectiveness of the training program. Nevertheless, considering that our research was a first step of a longer research series the current findings are promising. We have already started the implementation of the corrections with regard to both the test and the training program. It can be assumed that we may have reached higher effect size but our measurement tool was not sufficient enough to indicate it. This assumption is supported by the finding that the reliabilities of the subscales of the test were not as high. We have also reconsidered the training program. Due to the inherent assessment techniques in the program incorrectly functioning learning tasks can be identified empirically. Reconsidering instructional support has to be carried out as well. Further game elements such as background story, new graphical solutions, personalization could be added in order to improve motivation. Straightening the connection between learning material and the game characteristics is also an important aspect for further development.

Besides effectiveness methodological questions also has to be addressed in order to increase the generalizability of our findings. For instance, based on our results we cannot say anything about how effective our training could be compare to other programs. In addition, we could extend our design with the examination of placebo effects as well. The sampling of future studies should also be improved for example with randomized within subject research design. Investigation of further transfer effects (e.g. mathematical or science knowledge, other skills) also has to be carried out.

GENERAL DISCUSSION

Based on the experiences of the assessments and the experiment further fruitful research aims and developmental areas can be identified. Among these the most promising is the possible unification of technology-based assessment and digital game-based learning (Csapó et al, 2012; Pásztor, 2015b). Common attributes of the two fields such as immediate feedback, importance of optimal challenge, motivational environment, possibilities for interaction within the tasks, adaptive testing serve the theoretical basis for this endeavour. According to a basic model after completion of a test the system could offer digital teaching games (as a hyperlink) for the students to further improve their skills. After the training session pupils could return to the assessment part so they (and the teacher as well) could monitor the effects of the intervention. According to a more complex approach both the assessment and the training part could apply the advantages of adaptive testing methods. As result both the assessment and the training could be personalized, students could receive tasks which fit the most to their skills. It is important to note that this process could not be restricted only for inductive reasoning but it could be generalized and apply for any skills or knowledge domains.

This concept is one of the general aims of the eDia system developed by the Szeged Center for Research on Learning and Instruction. Besides the direct positive effects of such a system many indirect positive effects may occur. For instance during the implementation of our studies we provided documents for the schools about our researches such as assessment guides with the description of the constructs and feedbacks on the results. Thus, teachers could learn about current educational theories throughout the results of their pupils. It has to be noted that in online assessment teachers don't have to wait for the results compare to traditional assessment methods: everything could be at hand on one platform. Another significant difference is that technology based training could be carried out in large scale as well. Thereby the theory and practice could meet efficiently and teachers immediately could use the new knowledge in classroom teaching. In this context the eDia system could be considered as a platform for transferring knowledge between teachers and educational researchers. For instances it can happen that teachers never heard about the Klauer concept for training inductive reasoning. With experiments such as ours teachers can see the theory and the practice at the same time. This is important since the psychological concepts of Klauer's theory could easily be applied in everyday classroom teaching as well in any school subject: finding similarities and differences in relations and attributes is a general thinking process. Klauer and his colleagues also highlight the importance of the above mentioned aspects of their training program (Klauer, 1996; Klauer & Phye, 2008). In general, online assessments and developments of thinking skills could contribute to the improved efficiency of teaching processes and take us one step closer to the implementation of the thinking curriculum, too (about thinking curriculum see Adams, 1989; Nisbet, 1993; Resnick & Klopfer, 1989).

REFERENCES

Adams, M. J. (1989). Thinking skills curricula: Their promise and progress. *Educational Psychologist, 24*(1), 25–77.

Adey, P., Csapó, B., Demetriou, A., Hautamaki, J. és Shayer, M. (2007). Can we be intelligent about intelligence? Why education needs the concept of plastic general ability. *Educational Research Review, 2*(2), 75–97.

Barkl, S., Porter, A., & Ginns, P. (2012). Cognitive training for children: Effects on inductive reasoning, deductive reasoning, and mathematics achievement in an Australian school setting. *Psychology in the Schools, 49*(9), 828–842.

Binkley, M., Erstad, O., Herman, J., Raizen, S., Martin, R., Miller-Ricci, M., & Rumble, M. (2012). Defining Twenty-First Century Skills. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and Teaching of 21st Century Skills* (pp. 17–66). New York: Springer.

B. Németh, M. (1998). Az iskolai és hasznosítható tudás: természettudományos ismeretek alkalmazása. In B. Csapó (Ed.), *Iskolai tudás* (pp. 115–138). Budapest: Osiris Kiadó.

Csapó, B. (1994). Az induktív gondolkodás fejlődése. *Magyar Pedagógia*, *94*(1–2), 53–80.

Csapó, B. (1997). The development of inductive reasoning: Cross-sectional measurements in an educational context. *International Journal of Behavioral Development. 20*(4), 609–626.

Csapó, B. (Ed.). (1998a). *Az iskolai tudás*. Budapest: Osiris Kiadó.

Csapó, B. (1998b). Az új tudás képződésének eszköze: az induktív gondolkodás. In B. Csapó (Ed.), *Az iskolai tudás* (pp. 251–280). Budapest: Osiris Kiadó.

Csapó, B. (1999). Improving thinking through the content of teaching. In J. H. M. Hamers, J. E. H. van Luit, & B .Csapó (Eds.), *Teaching and learning thinking skills.* (pp. 37–62). Lisse: Swets and Zeitlinger.

Csapó, B. (2001). Az induktív gondolkodás fejlődésének elemzése országos reprezentatív felmérés alapján. *Magyar Pedagógia, 101*(3), 373–391.

Csapó, B. (2003a). *A képességek fejlődése és iskolai fejlesztése*. Budapest: Akadémiai Kiadó.

Csapó, B. (2003b). Az iskolai osztályok közötti különbségek és az oktatási rendszer demokratizálása. *Iskolakultúra, 13*(8), 107–117.

Csapó, B. (Ed.). (2004a). *Tudás és iskola*. Budapest: Műszaki Kiadó.
Csapó, B. (2004b). A pedagógiai értékeléstől a tanítási módszerek megújításáig: diagnózis és terápia. In B. Csapó (Ed.), *Tudás és iskola* (pp. 175–195). Budapest: Műszaki Kiadó.
Csapó, B. (Ed.). (2012). *Mérlegen a magyar iskola.* Budapest: Nemzeti Tankönyvkiadó.
Csapó, B. (2014). A szegedi iskolai longitudinális program. In J. Pál, & Z. Vajda (Eds.), *Szegedi Egyetemi Tudástár 7. Bölcsészet- és társadalomtudományok* (pp. 117–166). Szeged: Szegedi Egyetemi Kiadó.
Csapó, B., Fejes, J. B., Kinyó, L., & Tóth, E. (2014). Az iskolai teljesítmények alakulása Magyarországon nemzetközi összehasonlításban. In T. Kolosi, & I. Gy. Tóth (Eds.), *Társadalmi Riport 2014* (pp. 110-136). Budapest: TÁRKI.
Csapó, B., Lőrincz, A., & Molnár, Gy. (2012). Innovative assessment technologies in educational games designed for young students. In D. Ifenthaler, D. Eseryel, & X. Ge (Eds.), Assessment in game-based learning: foundations, innovations, and perspectives (pp. 235–254). New York: Springer.
Csapó, B., & Molnár Gy. (2012). Gondolkodási készségek és képességek fejlődésének mérése. In B. Csapó (Ed.), *Mérlegen a magyar iskola* (pp. 407–439). Budapest: Nemzeti Tankönyvkiadó.
Csapó, B., Molnár Gy., & Kinyó L. (2009). A magyar oktatási rendszer szelektivitása a nemzetközi összehasonlító vizsgálatok eredményeinek tükrében. *Iskolakultúra, 19*(3–4), 3-13.
Csapó, B., Molnár, Gy., Pap-Szigeti, R., & R. Tóth, K. (2009). A mérés-értékelés új tendenciái: a papír és számítógép alapú tesztelés összehasonlító vizsgálatai általános iskolás, illetve főiskolás diákok körében. In I. Perjés, & T. Kozma (Eds.), *Új kutatások a neveléstudományokban. Hatékony tudomány, pedagógiai kultúra, sikeres iskola* (pp. 99-108.) Budapest: Magyar Tudományos Akadémia.
Csapó, B., Molnár, Gy., & R. Tóth, K. (2008). A papír alapú tesztektől a számítógépes adaptív tesztelésig: a pedagógiai mérés-értékelés technikájának fejlődési tendenciái. *Iskolakultúra,* (3–4), 3-16.
Debreczeni, D. G. (2014). A digitális játék-alapú tanulási eszközök tervezésének pedagógiai alapjai. *Iskolakultúra, 24*(10). 15–27.
De Koning, E., & Hamers J.H.M. (1999). Teaching Inductive Reasoning: theoretical background and educational implications. In J. H. M. Hamers, J. E. H. van Luit, & B. Csapó (Eds.), *Teaching and learning thinking skills*. (pp 157–188). Lisse: Swets and Zeitlinger.
De Koning, E., Hamers, J. H. M., Sijtsma, K., & Vermeer, A. (2002). Teaching inductive reasoning in primary education. *Developmental Review,* 22, 211–241.
Dobi, J. (1998). Megtanult és megértett matematikatudás. In B. Csapó (Ed.), *Az iskolai tudás (*pp. 169–190). Budapest: Osiris Kiadó.
Elkonin, D. B., & Wenger A. L. (Eds.). (1988). *Особенности психического развития детей 6–7-летнего возраста*. Moszkva, Szovjetunió: Akadémiai Pedagógiai Tudományos Tanács.
Hamers, J. H. M., De Koning, E., & Sijtsma, K. (1998). Inductive reasoning in third grade: Intervention promises and constraints. *Contemporary Educational Psychology*, *23*(2), 132–148.
Hautamäki, J., Arinen, P., Hautamäki, A., Lehto, J., Lindblom, B., Kupiainen, S., Outinen, K., Pekuri, M., Reuhkala, M., & Scheinin, P. (2001). *Ensiaskeleet – oppimisen edellytykset: Luokanopettajille tarkoitetun seulan toimivuus Helsinki-aineiston perusteella.* [First steps – Prerequisities of learning: The functionality of the screening test for class teachers based on Helsinki-data]. City of Helsinki: Publication series A17: 2001.
Hempel, C., G. (1998). Az indukció újabb problémái. In J. Laki (Ed.), Tudományfilozófia. Budapest: Osiris Kiadó.
Klauer, K. J. (1989). *Denktraining für Kinder I.* Gottingen: Hogrefe.
Klauer, K. J. (1990). A process theory of inductive reasoning tested by the teaching of domain-specific thinking strategies. *European Journal of Psychology of Education, 5*(2), 191–206.
Klauer, K. J. (1996). Teaching inductive reasoning: Some theory and three experimental studies. *Learning and Instruction*, *6*(1), 37–57.
Klauer, K. J., & Phye, G. D. (1994). *Cognitive training for children. A developmental program of inductive reasoning and problem solving*. Seattle, WA: Hogrefe & Huber.
Klauer, K. J., & Phye, G. D. (2008): Inductive reasoning: A training approach. *Review of Educational Research, 78*(1), 85–123.
Klauer, K. J., Willmes, K., & Phye, G. D. (2002). Inducing inductive reasoning: Does it transfer to fluid intelligence?. *Contemporary Educational Psychology*, *27*(1), 1-25.
Korom, E. (1998). Az iskolai tudás és a hétköznapi tapasztalat ellentmondásai: természettudományos tévképzetek. In B. Csapó (Ed.), *Az iskolai tudás* (pp. 139–167). Budapest: Osiris Kiadó.
Kozma, R. (2009). Assessing and teaching 21st century skills: A call to action. In F. Scheuermann, & J. Bjornsson (Eds.), *The transition to computer-based assessment: New approaches to skills assessment and implications for large scale assessment* (pp. 13–23). Brussels: European Communities.
Magyar, A. (2012). Számítógépes adaptív tesztelés. *Iskolakultúra, 22*(6), 52–60.
Magyar, A. (2014). Adaptív tesztek készítésének folyamata. *Iskolakultúra 24*(4), 26–33.
Magyar, A., Pásztor, A., Pásztor-Kovács, A., Pluhár, Zs., & Molnár, Gy. (2015). A 21. században elvárt képességek számítógép alapú mérésének lehetőségei. In Z. Tóth (Ed.), *Új Kutatások a*

Neveléstudományokban. Oktatás és nevelés - gyakorlat és tudomány (pp. 230–243). Debreceni Egyetem: MTA Pedagógiai Tudományos Bizottság.
Molnár, Gy. (2006). Az induktív gondolkodás fejlesztése kisiskolás korban. *Magyar Pedagógia, 106*(1), 63–80.
Molnár, Gy. (2008a, November). *Az induktív gondolkodás fejlettsége kisiskolás korban*. Paper presented at the VIII. Országos Neveléstudományi Konferencia, Budapest. Abstract retrieved from http://www.staff.u-szeged.hu/~gymolnar/ONK_2008_mgy_ind_long.pdf
Molnár, Gy. (2008b). Kisiskolások induktív gondolkodásának játékos fejlesztése. *Új Pedagógiai Szemle, 58*(5), 51–64.
Molnár, Gy. (2010). Technológia-alapú mérés-értékelés hazai és nemzetközi implementációi. *Iskolakultúra,* (7–8), 22–34.
Molnár, Gy. (2011a). Playful fostering of 6- to 8-year-old students' inductive reasoning. *Thinking skills and Creativity, 6*(2), 91–99.
Molnár, Gy. (2011b). Számítógépes játék-alapú képességfejlesztés: egy pilot vizsgálat eredményei. *Iskolakultúra*, (6–7), 3–11.
Molnár, Gy. (2011c). Az információs-kommunikációs technológiák hatása a tanulásra és oktatásra. *Magyar Tudomány, 172*(9), 1038–1047.
Molnár, Gy. (2015). A képességmérés dilemmái: a diagnosztikus mérések (eDia) szerepe és helye a magyar közoktatásban. *Géniusz Műhely Kiadványok,* (2), 16–29.
Molnár, Gy., & Csapó, B. (2011). Az 1–11 évfolyamot átfogó induktív gondolkodás kompetenciaskála készítése a valószínűségi tesztelmélet alkalmazásával. *Magyar Pedagógia, 111*(2), 127–140.
Molnár, Gy., & Csapó, B. (2013, April). *Az eDia online diagnosztikus mérési rendszer*. Paper presented at the XI. Pedagógiai Értékelési Konferencia, Szeged. Abstract retrieved from http://www.edu.u-szeged.hu/pek2013/download/PEK2013_kotet.pdf
Molnár, Gy., Mikszai-Réthey, B., Attila Pásztor, A., & Magyar, T. (2012, August). *Innovative Assessment Technologies in Educational Games Designed for Integrating Assessment into Teaching.* Paper presented at the EARLI SIG1 Conference, Brussels, Belgium.
Molnár, Gy., & Pásztor, A. (2012, April). *The transition from single testing to complex systems of assessments.* Paper presented at the X. Pedagógiai Értékelési Konferencia, Szeged. Abstract retrieved from http://www.edu.u-szeged.hu/pek2012/download/PEK2012_kotet.pdf
Molnár, Gy., & Pásztor, A. (2015). A számítógép alapú mérések megvalósíthatósága kisiskolás diákok körében: első évfolyamos diákok egér- és billentyűzet-használati képességeinek fejlettségi szintje. *Magyar Pedagógia, 115*(3), 237–252.
Nagy, J. (2000). Összefüggés-megértés. *Magyar Pedagógia, 100*(2), 141–185.
Nagy, J., (2008). Az alsó tagozatos oktatás megújítása. In K. Fazekas, J. Köllő, & J. Varga (Eds.), *Zöld könyv a magyar közoktatás megújításáért* (pp. 53–69). Budapest: Ecostat.
Nagy, L.-né. (2013). Kisiskolások analógiás gondolkodásának fejlesztése a környezetismeret tantárgy keretében. In Gy. Molnár & E. Korom (Eds.), *Az iskolai sikerességet befolyásoló kognitív és affektív tényezők* (pp. 203–220). Budapest: Nemzedékek Tudása Tankönyvkiadó Zrt..
Nagy, L.-né. (2006). *Az analógiás gondolkodás fejlesztése*. Budapest: Műszaki Könyvkiadó.
Nisbet, J. (1993). The thinking curriculum. *Educational psychology, 13*(3–4), 281-290.
Pásztor, A. (2013). Digitális játékok az oktatásban. *Iskolakultúra, 23*(9), 37–48.
Pásztor, A. (2014). Lehetőségek és kihívások a digitális játék alapú tanulásban: egy induktív gondolkodást fejlesztő tréning hatásvizsgálata. *Magyar Pedagógia, 114*(4), 281–301.
Pásztor, A. (2015b). Computer-based assessment and development of inductive reasoning strategies. Szeged Workshop on Educational Evaluation, Szeged. Abstract retrieved from http://www.edu.u-szeged.hu/swee/eng/2015/SWEE_7_programfuzet_absztraktokkal.pdf
Pásztor, A., & Molnár, Gy. (2012). *Inductive reasoning in the first grade: comparing the effectiveness of a training program in 'face-to-face' and game-based environment.* Paper presented at the EARLI JURE conference, Regensburg, Germany.
Pásztor, A., & Rausch, A. (2013, November). *Számítógépes játékok szerepe a gondolkodási képességek fejlesztésében - kihívások és lehetőségek.* Paper presented at the XIII. Országos Neveléstudományi Konferencia, Eger. Abstract retrieved from http://onk2013.ektf.hu/wp-content/media/absztrakt-kotet-ONK-2013.pdf
Pásztor-Kovács, A., Magyar, A., Hülber, L., Pásztor, A., & Tongori, Á. (2013). Áttérés online tesztelésre - a mérés-értékelés új dimenziói. *Iskolakultúra, 23*(11), 86–100.
Pellegrino, J. W., & Glaser, R. (1982). Analyzing aptitudes for learning: inductive reasoning. In R. Glaser, (Ed.), *Advances in instructional psychology, Vol. 2.* (pp. 269–345). New Jersey: Lawrence Erlbaum Associates, Publishers Hillsdale.
Resnick, L. B. (1987). *Education and learning to think*. Washington, D. C.: National Academy Press.

Resnick, L. B., & Klopfer, L. E. (1989). *Toward the Thinking Curriculum: Current Cognitive Research. 1989 ASCD Yearbook*. Association for Supervision and Curriculum Development, 1250 N. Pitt St., Alexandria, VA 22314-1403.

Sloman, S. A., & Lagnado, D. (2005). The problem of induction. *The Cambridge handbook of thinking and reasoning*, 95–116.

Sternberg, R. J., & Gardner, M. K. (1983). Unities in inductive reasoning. *Journal of Experimental Psychology: General*, *112*(1), 80–116.

Tomic, W. (1995). Training in inductive reasoning and problem solving.*Contemporary educational psychology*, *20*(4), 483–490.

Tomic, W., & Kingma, J. (1998). Accelerating intelligence development through inductive reasoning training. In W. Tomic & J. Kingma (Eds.*), Conceptual issues in research on intelligence* (pp. 291–305). Stamford: CT: JAI.

Tomic, W., & Klauer, K. J. (1996). On the effects of training inductive reasoning: How far does it transfer and how long do the effects persist? *European Journal of Psychology of Education,* 3, 283–299.

Tóth, E., Csapó, B., & Székely, L. (2010). Az iskolák és osztályok közötti különbségek alakulása a magyar iskolarendszerben: egy longitudinális vizsgálat eredményei. *Közgazdasági Szemle, 57*(9), 798–814.

Young, M. F., Slota, S., Cutter, A. B., Jalette, G., Mullin, G., Lai, B., Simeoni, Z., Tran, M., & Yukhymenko, M. (2012). Our princess is in another castle: A review of trends in serious gaming for education. *Review of Educational Research*, *82*(1), 61–89.

Wouters, P., van Nimwegen, C., van Oostendorp, H., & van der Spek, E. D. (2013). A meta-analysis of the cognitive and motivational effects of serious games. *Journal of Educational Psychology*, *105*(2), 249–265.

Wouters, P., & Van Oostendorp, H. (2013). A meta-analytic review of the role of instructional support in game-based learning. *Computers & Educatio*n, *60*(1), 412–425.

PUBLICATIONS IN CONNECTION WITH THE DISSERTATION

Csapó, B., Rausch, A., & Pásztor, A. (2016, August). *Online Assessment of Early Numeracy and Reasoning*. Paper presented at the EARLI SIG 1 Conference, Munich, Abstract retrieved from https://www.conftool.com/earli-sig1-2016/index.php?page=browse Sessions&search=p%C3%A1sztor

Molnár, Gy., Lőrincz, A., Pásztor, A., & Csapó, B. (2015, August). *Internet-based development of thinking skills in young schoolchildren.* Paper presented at the 16th European Conference for the Research on Learning and Instruction, Limassol, Cyprus. Abstract retrieved from http://www.earli2015.org/media/EARLI2015/docs/EARLI2015_bookOfAbstracts.pdf

Molnár, Gy., Mikszai-Réthey, B., Attila Pásztor, A., & Magyar, T. (2012, August). *Innovative Assessment Technologies in Educational Games Designed for Integrating Assessment into Teaching.* Paper presented at the EARLI SIG1 Conference, Brussels, Belgium.

Molnár, Gy., & Pásztor, A. (2012a, April). *The transition from single testing to complex systems of assessments.* Paper presented at the X. Pedagógiai Értékelési Konferencia, Szeged. Abstract retrieved from http://www.edu.u-szeged.hu/pek2012/download/PEK2012_kotet.pdf

Molnár, Gy. & Pásztor, A. (2012b, April). *Game-based development of thinking skills.* Szeged Workshop on Educational Evaluation, Szeged. Abstract retrieved from http://www.edu.u-szeged.hu/swee/eng/2012/SWEE_4_program_absztraktokkal.pdf

Molnár, Gy., & Pásztor, A. (2015, November). *A számítógép alapú tesztelés megvalósíthatósága kisiskolás korban: egér - és billentyűzethasználati képességek fejlettségi szintje.* Paper presented at the XV. Országos Neveléstudományi Konferencia, Budapest. Abstract retrieved from http://onk2015.conf.uni-obuda.hu/wp-content/uploads/2015/01/ONK_2015_tartalmi_osszefoglalok.pdf

Molnár, Gy., & Pásztor, A. (2015). A számítógép alapú mérések megvalósíthatósága kisiskolás diákok körében: első évfolyamos diákok egér- és billentyűzet-használati képességeinek fejlettségi szintje. *Magyar Pedagógia, 115*(3), 237–252.

Pásztor, A. (2013). Digitális játékok az oktatásban. *Iskolakultúra*, *23*(9), 37–48.

Pásztor, A. (2014a). Lehetőségek és kihívások a digitális játék alapú tanulásban: egy induktív gondolkodást fejlesztő tréning hatásvizsgálata. *Magyar Pedagógia, 114*(4), 281–301.

Pásztor, A. (2014b, May). *Playful Fostering of Inductive Reasoning through Mathematical Content in Computer-Based Environment.* Paper presented at the 12th Conference on Educational Assessment, Szeged. Abstract retrieved from http://www.edu.u-szeged.hu/pek2014/download/PEK_2014_kotet.pdf

Pásztor, A. (2015). Computer-based assessment and development of inductive reasoning strategies. Szeged Workshop on Educational Evaluation, Szeged. Abstract retrieved from http://www.edu.u-szeged.hu/swee/eng/2015/SWEE_7_programfuzet_absztraktokkal.pdf

Pásztor, A. (2016a). Development of inductive reasoning between kindergarten and fourth grade. Szeged Workshop on Educational Evaluation, Szeged. Abstract retrieved from http://www.edu.u-szeged.hu/phd/people/apasztor/PDF/Pasztor_2016_Development%20of%20inductive%20reasoning_SWEE_2016.pdf

Pásztor, A. (2016b). Online diagnostic assessment of classification in the beginning of schooling. In C. Csíkos, A. Rausch, & J. Szitányi (Eds.), *Proceedings of the 40th Conference of the International Group for the Psychology of Mathematics Education*, Vol. 1, p. 219. Szeged, Hungary: PME.

Pásztor, A., & Molnár, Gy. (2015, November). *Induktív gondolkodás technológia alapú mérésének lehetőségei az iskola kezdő szakaszában.* Paper presented at the XV. Országos Neveléstudományi Konferencia, Budapest. Abstract retrieved from http://onk2015.conf.uni-obuda.hu/wp-content/uploads/2015/01/ONK_2015_tartalmi_osszefoglalok.pdf

Pásztor, A., & Molnár, Gy. (2016, April). *Online assessment of inductive reasoning at primary school entrance.* Paper presented at the 14th Conference on Educational Assessment, Szeged. Abstract retrieved from http://www.edu.u-szeged.hu/pek2016/wp-content/uploads/2015/11/PEK2016_kotet_v.pdf

Pásztor, A., & Rausch, A. (2013, November). *Számítógépes játékok szerepe a gondolkodási képességek fejlesztésében - kihívások és lehetőségek.* Paper presented at the XIII. Országos Neveléstudományi Konferencia, Eger. Abstract retrieved from http://onk2013.ektf.hu/wp-content/media/absztrakt-kotet-ONK-2013.pdf

I carried out the empirical studies by using the infrastructure of the Center for Research on Learning and Instruction, University of Szeged, the MTA-SZTE Research Group on the Development of Competencies and the Doctoral School of Education, University of Szeged. I received the Apáczai Csere János Doctoral Scholarship in the academic year of 2013 to 2014.