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**THE DEVELOPMENT AND IMPROVEMENT OF THE
SYSTEMATIZING ABILITY AMONG 4–10-YEAR-OLD
CHILDREN**

Theses of PhD Dissertation

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INTRODUCTION

The paper focuses on the systematizing ability. It refers to the system of psychic components that underline the process of making comparisons and recognizing relationships (Nagy, 2007). The foundations of the systematizing ability are based on the work of Piaget. The logic of classes and relations is a system of specific operations in which classification, recognizing relations and the system of logical operations are all linked together (Inhelder & Piaget, 1967; Piaget, 1969).

The research described in this paper focuses on the development of the systematizing ability both on the enactive and the symbolic level. The characteristics of the developmental processes, the relationship between the two levels, how they are interdependent as well as the aspects that influence development are all detailed through the results of empirical studies. The paper presents methods and instruments to facilitate a continuous, criterion-based developmental process which connects the enactive and the symbolic level of the systematizing ability. This creates the possibility to improve the ability in a comprehensive way from the preschool group of 4–5-year-olds until grade 4 of the elementary school.

The first four sections of the paper provide a literature review. They describe how the concept of the systematizing ability evolved. The structure of the ability is also discussed in detail. Moreover, the role of the systematizing ability is examined in an international context. Research on how to improve cognitive skills is summarized from the perspective of whether it is possible to improve the systematizing ability. Specific sections are dedicated to the possibilities of improving the abilities of preschool and junior section children through games and content-based methods.

The empirical studies described in this paper focus on the development and improvement of the systematizing ability. The first study describes the steps of developing a criterion-oriented, diagnostic instrument which measures the basic systematizing ability. A specific section is dedicated to the results of a national, longitudinal study, which used a tested, revised instrument and involved more than 10 000 participants. The paper gives account of a comparative study, which compared the results of majority students in a national study in grade 1, 3, 5 and 7 with the results of students with mild intellectual disabilities. The correlations of the level of development of the enactive and the symbolic level of the systematizing ability are also analyzed. Furthermore, the paper describes the methods that were developed to improve the enactive level as well as the results of an intervention program. A separate section dealing with the possibilities of improving the symbolic level describes the available methods and the results of an intervention program aimed at improving the symbolic level relying on a content-based approach.

LITERATURE REVIEW

The starting point of the research is the system of competences by József Nagy. The systematizing ability is the basic skill of cognitive competence. Its structure is based on Piaget's logic of classes and relations (Piaget & Inhelder, 1975, 1976). Its functioning involves recognizing, systematizing and sorting signs, objects, hierarchies of concepts, collecting them into sets as well as defining and classifying concepts (Nagy, 1987, 2003, 2010).

Typically, the basic systematizing ability develops around age 4–8. As cognition develops, the focus from the enactive level shifts to the symbolic level. While young children sort, group and create sets on the enactive level, school age children perform such operations with concepts. The relationship of the two levels of abstraction, their dependence on one another can be examined in relation to the systematizing ability, and the results can serve as guidelines in the development of improvement methods.

The systematizing ability consists of basic skills. In general, the development of skills can be characterized by the continuous decline of conscious control as the level of automation increases. *Csikos* (2016) interprets conscious practice as the application of the strategic components of reasoning, which is essential in the developmental process of skills and abilities.

Traditionally, the operations of the systematizing ability are associated with mathematics, therefore the characteristics of operations like classification or seriation, for example, were examined in relation to learning math in the international literature (*Gallagher & Reid*, 2002; *Kingma*, 1984; *Körner*, 2005). Results show that there is a clear relationship between basic systematizing skills and basic numerical skills. So, for example, a prominent role is attributed to seriation in the developmental process of the concept of numbers (*Aunola, Leskinen, Lerikkanen & Nurmi*, 2004; *Desoete, Stock, Schepens, Baeyens & Roeyers*, 2009).

Recent research has been focusing on the relationship between the level of development of cognition in early years and school success in later years. The results of studies on the predictive role of mathematical skills in early years unequivocally showed that the level of development of mathematical skills in early years is predictive of school success in later years. When examining the role of the systematizing ability, researchers found that seriation and classification were critical predictors of the development of numerical and mathematical skills (*Dumont*, 1994; *Duncan, Dowsett, Claessens, Magnuson, Huston, Klebanov, Pagani, Feinstein, Engel, Brooks-Gunn, Sexton, Duckworth & Japel*, 2007).

The act of playing in preschool years and cognitive development are strongly related. Research has unambiguously confirmed that the act of playing in preschool years facilitates cognitive development, more specifically the development of reasoning, creativity and communication (*Barnett* 1998; *Bateson & Martin*, 2013; *Lillard, Lerner, Hopkins, Dore, Smith & Palmquist*, 2013; *Singer, Golinkoff & Hirsh-Pasek*, 2006). If spontaneous, free play is enriched with guided play that facilitates the development of specific areas of cognition, the act of playing can have an even more powerful role in the development of those specific areas. This approach was followed when developing the training programs of the DIFER test battery (*Fazekasné*, 2006; *Józsa*, 2014; *Miskolcziné & Nagy*, 2006; *Nagy*, 2009; *Zsolnai*, 2006).

Improvement methods concerned with the symbolic level of cognition can be embedded in the content of school subjects. These programs are based on the assumption that cognitive skills are connected to knowledge, which is therefore used as a mediator in the process of improving cognitive skills. School textbooks are full of texts where the information is grouped and organized and contains relations. This information becomes part of our active knowledge with the help of our cognition. Therefore, these texts are suitable for improving reasoning and cognitive skills. In order to read and write efficiently, students need to know how to systematize the information they hear and efficiently use linguistic and logical operations (*Molnár & Cs. Czachesz*, 2003). Thus linguistic and cognitive improvement can reinforce one another.

Research has been dealing with the development and reordering of the symbolic system as well as with the structure of knowledge (*Korom*, 2005; *Tóth*, 2005). The systematizing ability plays an important role in efficiently organizing concepts into systems. Improving the ability indirectly contributes to the development of comprehension and transferable knowledge.

Even on an international level, few research has focused on comparing the cognitive skills of majority students with that of students with mild intellectual disabilities. Cognitive operations of students with mild intellectual disabilities are characterized by inactive reasoning and lack of searching for productive solutions (*Klauer*, 2007; *Mesterházi*, 1998; *Strobel & Warnke*, 2007a, 2007b). These deficient abstract cognitive processes set back abstraction and understanding of rules. Thus knowledge cannot be transferred, and reasoning becomes static (*Lorenz*, 2007; *Mesterházi*, 1991).

The literature review describes the development of systematizing skills according to the theoretical model of the systematizing ability. It differentiates between the enactive and

cognitive level of the ability, and reviews the research on the relationship between the different levels of abstraction of cognition. It presents the results that confirm the predictive role of systematizing skills on school success in later years. Preschool and school improvement possibilities are also reviewed. Furthermore, the characteristics of the cognition of students with mild intellectual disabilities are discussed and compared to that of majority students.

DESCRIPTION OF THE EMPIRICAL RESEARCH, METHODS, RESEARCH QUESTIONS

The empirical research focuses on the development and improvement of the systematizing ability. A comprehensive objective is to develop a framework for the criterion-oriented improvement both on the enactive and on the symbolic level, thus giving way to the facilitation of cognition across the different levels of abstraction.

The research questions cover three main topics:

1. *Cross-sectional study for the development of the systematizing ability among 4–10-year-old children.* The aim was to develop diagnostic, criterion-oriented instruments to explore how the enactive and the symbolic levels of the systematizing ability develop.
 - 1.1. Is the reliability and validity of the test that measures the enactive systematizing ability of 4–8-year-old children acceptable?
 - 1.2. What are the developmental characteristics of the enactive systematizing ability among 4–8-year-old children?
 - 1.3. Is the reliability and validity of the test that measures the symbolic systematizing ability of 8–10-year-old children acceptable?
 - 1.4. What are the developmental characteristics of the symbolic systematizing ability among 8–10-year-old children?
 - 1.5. What is the relationship in the development of the enactive and the symbolic systematizing ability like?
 - 1.6. What are the differences in the development of the enactive systematizing ability of majority students and students with mild intellectual disabilities?
2. *Developing methods to improve the systematizing ability of 4–10-year-old children.* The aim was to develop criterion-oriented methods for the improvement of the systematizing ability both on the enactive and on the symbolic level.
 - 2.1. Is it possible to develop methods that improve the basic systematizing ability on the enactive level in a criterion-oriented way through games?
 - 2.2. Is it possible to develop content-based methods for the improvement of the symbolic systematizing ability that can be applied in the classroom?
3. *Experimental application of the methods aimed at improving the systematizing ability.* Practical application of the methods to improve the enactive and the symbolic systematizing ability and studying their efficiency.
 - 3.1. Can the efficacy of the playful facilitation of the basic systematizing ability among preschool children be verified?
 - 3.2. Can the efficacy of the content-based improvement of the symbolic systematizing ability in grade 3 and 4 be verified?
4. *Exploring the factors that influence the development of the systematizing ability.*
 - 4.1. Which background variables influence the development of the systematizing ability?

Methods

Our empirical study measures the level of development of the systematizing ability. We measured the ability on two different levels of abstraction: (1) basic, enactive level, which was measured among children aged 4–8; (2) symbolic level, which was measured among 8–10-year-old students. We used two different instruments to measure the systematizing ability on these two levels. Both instruments are based on the research of *József Nagy*, who developed a system of tests consisting of 125 tasks (260 items), which included enactive tasks, tasks with images as well as tasks testing formal operations. Our test development process was based on the structure of skills and abilities *Nagy* prepared in 1980 (*Nagy*, 1980).

The basic systematizing ability test is an individual, face-to-face test containing enactive tasks. It takes 10–15 minutes per child to take the test. The symbolic systematizing ability test is a group test. The structure of the two tests is similar.

Children were administered the RAVEN intelligence test. Parental education was used as the family background index. During the pre- and post-tests of the preschool intervention program, the level of development of the combinative ability and the skills and abilities measured by DIFER were measured.

An intervention program, using a control group, was organized to improve the basic systematizing ability. Systematizing operations were improved through playful activities. These activities were maximum 10–20 minutes long, and they were initiated by preschool teachers on a daily basis. These frequent but short activities ensure the cognitive operations under improvement are continuously in use.

The symbolic level of the systematizing ability was improved through content-based methods. It enables improvement of the components of a specific skill to be in use in various subjects for several months until optimal efficiency is reached. Skill improvement tasks were embedded in the content of the subjects called Hungarian language and literature and Science for grade 3 and 4 students. Ten key topics were picked in one academic year which were enriched with tasks that improved the components of the skills in question. Facilitation was continuous throughout the year. Typically it meant few-minute tasks at the beginning of each lesson.

The logic of the studies

The empirical research covers the results of six studies. Data collections took place between 2010 and 2015 in several batches within the framework of two programs conducted by *Krisztián Józsa* and supported by the Hungarian Scientific Research Fund, OTKA: “Criterion-referenced education” (2007–2011) and “Criterion-referenced ability development between the ages 4–12” (2011–2016).

(1) The first data collection took place in the fall of 2010. The objectives of the first pilot study were to develop and test an instrument measuring the enactive systematizing ability (*Zentai*, 2010). Based on the results of the pilot study, the instrument was revised and this revised instrument was used in later studies. In 2011, we launched a small sample, longitudinal study to explore the correlations of the enactive and the symbolic levels of the systematizing ability.

(2) In the fall of 2012, we conducted a national, representative cross-sectional study to explore how the enactive systematizing ability develops.

(3) A comparative study involving students with mild intellectual disabilities was performed (*Zentai, Fazekasné & Józsa*, 2013).

(4) Two studies were organized to explore the correlations of the enactive and symbolic levels of the systematizing ability. One of the studies, which took place in 2013, involved students from grade 3. Students level of development was measured at one point of measurement on different levels of abstraction. The longitudinal study ran between 2011 and 2013 (*Zentai & Józsa, 2015; Zentai, Józsa & Molnár, 2016*).

(5) In the fall of 2012, a control group intervention program was launched in order to test the methods developed to improve the systematizing ability and describe their impacts. The post-test of the preschool intervention program took place in the spring of 2013 (*Zentai, 2014; Zentai & Józsa, 2014*).

(6) In 2011, a content-based program was launched to improve the symbolic systematizing ability. It involved students from grade 3 and 4 (*Zentai, 2012*).

Samples

The samples of the six studies performed as part of the empirical research are detailed for each study.

1. The sample of the pilot study consisted of 4–5-year-old (N=48) and 5–6-year-old (N=50) children as well as children from grade 1 (N=232) and grade 2 (N=50) of the elementary school.
2. The sample of the national, representative study consisted of 312 4–5-year-old children, 537 5–6-year-old children, 3743 children from grade 1, 3343 children from grade 2 and 3331 children from grade 3 of the elementary school.
3. As for the comparative study involving children with mild intellectual disabilities, the sample of majority students was the same as in the national, representative study (312 4–5-year-old children, 537 5–6-year-old children, 3743 children from grade 1, 3343 children from grade 2 and 3331 children from grade 3 of the elementary school). The sample of students with mild intellectual disabilities consisted of 132 students from grade 1, 152 students from grade 3, 154 students from grade 5 and 168 students from grade 7 of the elementary school.
4. We used two different study designs to explore the relationships between the enactive and symbolic levels of the systematizing ability. The sample of the study focusing on grade 3 students consisted of 263 students from grade 3 of the elementary school. Our second study was a longitudinal one. The first data collection took place while students attended grade 1, while the post-test was administered when students attended grade 3. Data from both assessments are available from 197 students.
5. The preschool sample for the skills improvement program consisted of 4–5-year-old children. The experimental group consisted of 85 children, whose systematizing ability was improved continuously for 9 months. The skills of the control group members were not improved with the methods developed within the framework of this research, preschool teachers carried out their usual duties in this group, but the same measurements were administered here as in the experimental group. The control group consisted of 145 4–5-year-old children.
6. In the experimental group, the symbolic level of the systematizing ability was improved through content-based methods for 2 academic years. In the control group, only data collection took place, no improvement was performed. The experimental group consisted of 247 children, while the control group consisted of 170 children in total.

RESULTS

The development of the systematizing ability

Before improving basic skills, their level of development must be measured. A criterion-oriented, diagnostic evaluation is most appropriate for this purpose (Nagy, 2000a; Vidákovich, 1990). Criterion-oriented evaluation means that instead of comparing individual results to the average of the population, they are compared to a predefined, optimal level of development. Basic skills should be improved until the individual reaches the optimal level of development. Diagnostic evaluation helps to identify which components are not working properly. Improving and developing these components is required until the predefined criterion of facilitation is reached (Nagy, 2000a; Vidákovich, 1990).

The research presented in this paper was based on the paradigm of criterion-oriented skills improvement (Nagy, 2000a, 2010). One of the aims was to develop additional instruments for the improvement of the basic system of personality. The DIFER test battery works with similar instruments (Nagy, Józsa, Vidákovich & Fazekasné, 2004). Within the framework of this research, criterion-oriented, diagnostic instruments were developed to measure the systematizing ability. The enactive test measuring the basic systematizing ability can be used for children aged 4–8. It is an individual test which follows the structure of the DIFER tests. Test development was based on the theoretical model of the systematizing ability by József Nagy (Nagy, 2000, 2010). Test tasks followed the structure of this model. Based on the experiences gained through pilot testing, revisions were made to the instrument, and this revised instrument was tested on a national sample. The sample of our cross-sectional study involved more than 10 000 children from 4–5-year-old preschool groups to grade 3 of the elementary school. With the help of the results of the national study, the standards for each year were created, the developmental process of the systematizing ability was described, and the minimum requirements of acquisition for the different levels of the ability were defined. Furthermore, a so-called notebook of development index was created to record test results, which is important both in terms of identifying the areas where improvement is needed as well as of controlling the effectiveness of the intervention program.

The results of majority students in the national, cross-sectional study were used in a comparative study as well. Students with mild intellectual disabilities in grade 1, 3, 5 and 7 filled out the enactive test so that their level of cognitive development could be compared with that of majority students. Students with mild intellectual disabilities are, on average, 3 years lagging behind in terms of the enactive level of the systematizing ability. These results correspond to the results of comparative studies that were carried out with the help of DIFER tests (Józsa & Fazekasné, 2006a, 2006b).

The nature of development may be identified as operation on a higher level of abstraction. The research intended to capture this by comparing the level of development of the systematizing ability on the enactive and the symbolic level. Results confirmed that there are correlations between the two levels of abstraction, however, there is no clear hierarchy between the two levels. These results replicate the contradictions found in international studies. Some studies support the idea of the two levels building on one another, while other studies support the idea that the two systems are independent from each other (Baillargeon & Wang, 2002; Cohen, Harold & Cashon, 2002; Johnson, 2001).

Improving the systematizing ability

The paper presented the development and testing of criterion-oriented methods to improve the systematizing ability. These methods were based on the results described in the

sections of this paper dealing with the development of the ability. With the help of these methods, a continuous, criterion-oriented intervention program can be realized from age 4–5 up until grade 4 of the elementary school. This comprehensive program improves both the enactive and the symbolic levels of the systematizing ability. enactive facilitation was realized through games. The motivational impact of this joyful activity further adds to the efficacy of the program. The symbolic level of the systematizing ability was improved through content-based methods. Students solved few-minute tasks on Hungarian language and literature and Science classes every day where they had to use the operations of the systematizing ability. This content-based improvement strategy facilitates skills development and supports acquisition of the school content at the same time. At the beginning, symbolic improvement should be carried out together with the improvement of the enactive level, while in later stages of the program the symbolic level can be improved on its own. This idea is based on the findings of the studies performed within the framework of the research presented in this paper. Development of the enactive level of the systematizing ability is most intense in preschool, in the group of 4–5-year-old children, therefore playful facilitation is recommended. Once children start school, the focus should be shifted to both abstraction levels. For students whose basic level is not yet developed, playful facilitation and content-based improvement can go hand-in-hand.

The paper described the methods to improve the systematizing ability on two different levels of abstraction. Both methods rely on research dealing with criterion-oriented improvement. The methodology of playful facilitation matches the methods of the DIFER program. It offers joyful and playful situations where the basic skills in question are in use. In terms of systematizing, enactive, physical activities were developed that require children to use set operations, classification and seriation. The methodology of the content-based improvement program was adapted from previous, validated research, which involved students from grade 5 and 6, to be suitable for children in grade 3 and 4. The theoretical framework was the same, however, new tasks were developed for the younger generation. Students solved few-minute tasks in Hungarian language and Science classes where they had to create sets, classify and sort the concepts learned on these lessons. The methods developed for the improvement of the systematizing ability build on one another to offer comprehensive facilitation from the preschool group of 4–5-year-olds until grade 4 of the elementary school. With the help of the methods described in this research as well as with the program previously developed for students at grade 5 and 6, a continuous improvement program can be realized until grade 6 of the elementary school.

Results have unequivocally confirmed that these improvement methods can accelerate the development of the systematizing ability. The program was most effective for children whose level of development was lower at the beginning of the improvement program. This was true for both the playful facilitation and the content-based improvement.

Conclusions of the background studies

The system of studies described in this paper opens a number of possibilities to add background variables. The role of the family background was examined in several studies. A unambiguous relationship was found between parental education levels and the level of development of the systematizing ability in the majority students' sample. The higher the parental level of education is, the higher the level of development of the child's systematizing ability is. This is true in all age groups, the relative disadvantage of low parental education level prevails for years. These results correspond to the results of previous research on development (Csapó, 1998; Józsa, 2004; Józsa & Zentai, 2007a, 2007b). The relationship between the level of development of the systematizing ability and parental educational level is not so strong in

the sample of students with mild intellectual disabilities. In this sample, the level of development is almost independent of the parental level of education. This supports the idea that students with mild intellectual disabilities are lagging behind in development due to organic reasons.

Practical implications

The paper presented the theoretical framework and the empirical results of a 6-year program aimed at improving the systematizing ability. Teachers can directly incorporate the instruments and methods that were developed as part of this program into their everyday teaching work. A book containing the instrument for measuring the enactive systematizing ability and a collection of games to improve it primarily at preschool is under publication (Józsa, Zentai & Hajduné, 2017a, 2017b). After its publication it will be available for teachers similarly to the DIFER package. The basic systematizing ability test is compatible with the DIFER tests and helps educational professionals to get a comprehensive picture of the level of development of the system of basic cognitive skills. The instruments and methods that were developed for the improvement of the symbolic level are also ready to be made public for teachers.

On the other hand, teachers should also be acquainted with the approach of diagnostic and criterion-oriented evaluation and improvement. Diagnostic tests are the starting point for effective skills improvement. Therefore, trainings were also developed for teachers so that they can get to know this approach and learn these effective improvement methods.

Further research

There are several viewpoints to look at the development and improvement of cognitive skills. The criterion-based strategy provides a theoretical framework to make a powerful step towards improving cognitive skills. Reviewing the literature, some open questions and contradictions were found which should be further investigated.

The correlations of the enactive and the symbolic systematizing require further attention, too. Based on the relative independence of the two levels, the paper assumes that there are specific skills, especially linguistic skills that play an important role in the development of symbolic systematizing. Symbolic development, preliminary knowledge of the concepts of different school subjects and the possible misconceptions that are formed are all relevant aspects that may have an impact on the development of the symbolic systematizing ability. Exploring all the aspects that play an influential role in the development of the symbolic systematizing ability is essential in order to find effective, content-based ways to improve this ability in any subject.

In recent years more and more focus is put in educational research to examine the relationship of the level of development of skills at preschool and school success. The research described in this paper has established a longitudinal database with the first point of measurement at preschool, among 4–5-year-old children. Basic cognitive skills of the participants were measured every year until students reached grade 8 of the elementary school. That is, there is a database covering 10 years of skills development with a focus on the development of the systematizing ability. In this research, the level of development at preschool was linked to the results of the national measurement of competence in grade 6 and 8. Currently, data analysis is in progress. These results can help to define how predictive the level of development of the systematizing ability at preschool is in grade 6 and 8.

Improving skills and motives that strengthen one another can be effective in self development. When developing games to improve the systematizing ability, we specifically

built on the impact of motivational drive. Games and joyful activities motivate students and improve their skills at the same time. The impact of motivation on the development of the systematizing ability was out of scope for this research. Further research is needed to examine the relationship of motivation and the systematizing ability in order to justify our assumptions.

The research also examined the population of students with mild intellectual disabilities. It is important to provide instruments and methods in the education of both majority students and students with special needs that are applicable to both populations and provide comparative data on development. We performed a comparative study to define the developmental characteristics of the systematizing ability in both populations. Future studies will focus on developing new ways to improve the systematizing ability. We are planning to test the methods developed for majority students to improve the ability through games among students with mild intellectual disabilities.

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