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Theses for doctoral (PhD) dissertation

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The impact of classroom coordination skills development on mathematics learning: targeting lower secondary school pupils

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Contect

INTRODUCTION

The challenges of the third millennium have not left education untouched. The dawn of a new era and the acceleration of the development of the educational environment bring with them the need for change in terms of educational methodology. It is becoming increasingly apparent that the old, tried and tested ways of working and methods of teaching are less attractive and less effective for the alpha generation. In the face of these inevitable and inescapable changes, the teaching profession needs to seek answers to questions that are difficult to answer clearly. What teaching methods and tools should and should not be used in our classroom teaching to support a holistic approach to teaching and learning? Are there universal ways of working and methods that meet the educational needs of the 21st century? Are we able to support the design of a modern/innovative learning environment, where the focal points are:

- be learner-centred,
- be knowledge-centred,
- is evaluation-oriented, ez itt nem egyértelmű (az a cél hogy evaluation-oriented legyen akkor be evaluation oriented vagy jelenleg az?
- be community-centred,
- take into account prior knowledge and individual differences,
- offer learning programmes that challenge everyone,
- support horizontal networking in knowledge areas and subjects,
- support cooperative learning,
- finally, account for motivation and emotions in terms of expected outcomes (Komenczi, 2016; OECD, 2017; Révész, 2019).

As is well known, the National Curriculum is one of the fundamental documents regulating the content of education in Hungary. In its current version, the NAT2020, *active learning* and its support from the pedagogical side is emphasised, which requires students to actively participate in learning activities. It identifies as the main aim of learning activities the development of competences that enable learners to use the knowledge acquired in a creative way in different situations. Furthermore, *activity-based learning organisation* helps students to acquire knowledge in a deeper way. From the pedagogical point of view, it is desirable to promote the benefits of cooperative learning and *differentiated* individual *work.* In addition, schools should seek to include in their local curricula lessons that focus on (*multidisciplinary*) themes requiring the *integration of* *knowledge from* several *subjects.* The thesis is also written in the spirit of interdisciplinarity, where parts of the mathematics curriculum are taught through a movement-based lesson using an innovative sports tool.

The beneficial effects of physical activity have been demonstrated across a range of indicators in addition to sport performance (Vazou et al, 2019). There is a growing body of research that examines the beneficial effects of physical activity on learning processes in relation to school time. Researchers and educationalists are increasingly turning their attention to physical activity in the classroom because of its potential to positively influence learning outcomes, to induce positive changes across a broad spectrum of personality and to increase 'more than just' children's physical activity levels. Class-level systematic reviews and meta-analyses suggest that both short- and longer-term physical activity-based interventions have beneficial effects on health, cognition and academic performance (Daly-Smith et al., 2018; Martin and Murtagh 2017; Norris et al., 2020; Watson et al., 2017).

This is how we arrive at the birth of *physically active learning* - FAT. FAT is a pedagogical approach where learners acquire learning content while being physically active (Bartholomew et al., 2017).

In the new method, I refer to the learning support tools used in FAT teaching as FAT teaching tools. The FAT teaching tool used in the primary research was Variable Sports Ladder 3D, VSL3D for short.

OBJECTIVE

The main objective of the research is to investigate the effectiveness of *Physically* Active *Learning* (FAT) on the acquisition of mathematics content, the improvement of students' algebraic and geometric performance and their subject preference in lower secondary school.

RESEARCH QUESTIONS AND HYPOTHESES

Research questions

1. What is the relationship between the use of FAT in the classroom and changes in mathematical performance?

2. How can the impact of FAT intervention be characterised at different grades?

3. What is the change in the algebraic and/or geometrical type of problems as a result of the intervention?

4. How does the intervention change students' attitudes towards mathematics?

5. What are the experiences, opinions and evaluations of teachers on the VSL3D sport/system/system and its use in the FAT mindset?

Hypotheses of the research

H1: I hypothesize that there will be a positive relationship between the regular use of FAT in mathematics lessons and changes in subject achievement.

H2: I hypothesize that the FAT lesson will result in a positive change in the cognitive and affective spheres of the students involved in the intervention.

H3: I assume that the performance improvement for algebraic tasks will be larger than for geometric ones.

H4: I hypothesize that subject attitudes and the place of mathematics on the subject preference list will change in a positive direction as a result of the intervention.

H5: I assume that teachers will positively evaluate the intervention and discover the differentiated development potential of FAT teaching.

MATERIAL AND METHOD

Sampling

The research was carried out in five educational institutions (A-E), with ten classes of lower secondary school (excluding year 1) The sample of the pedagogical experiment, which was basically a two-group experiment, consisted of class teachers and lower secondary school pupils: N=240.

Institution	Region	Year group tested	Number of groups of pupils in the year group	Number of pupils tested per person
A	West Hungary	4.	2	55
B	West Hungary	3.	2	47
C	Central Transdanubia	3.	2	65
D	West Hungary	2.	2	46
E	West Hungary	2.	2	42

Specificities of the pupil sample

Two groups of students from each grade took part in the educational experiment. One group used traditional classroom teaching (control group), the other group used physically active teaching (FAT) (experimental group). The frequency of the use of the ladder in mathematics literacy varied from grade to grade. The reason given for this is to gain a deeper understanding of the impact system.

Taking into account recommendations from the literature, students who:

- ✓ had learning difficulties, attention problems or health conditions that limited their physical activity,
- ✓ an additional exclusion criterion was missing more than 5% of FAT maths lessons,

After the exclusions, the sample of pupils is: $n_{pupils} = 230$.

Specificities of the teaching model

The teachers of the classes were included in the sample. They were not excluded. Throughout the programme, each teacher worked with his/her own class, using the same curriculum. The number of teachers in the five institutions: $n_{teachers} = 10$.

Data exploration methods

I want to demonstrate and validate the effectiveness of FAT tutoring by detecting changes in students' cognitive and affective domains.

The methods used in the series of studies - data exploration and data analysis - are outlined in the table, with a description of the people, areas, grades, instruments and their characteristics.

Retrieved from Persons	Area under investigation	Vintage	Test tools/ Methods	Investigation feature	Data analysis
Students	Cognitive	2., 3., 4.	Knowledge measurement worksheet	94 points, 6 tasks 100 points,10 tasks	quantitative
	Affective	2., 3.	Measuring love of the subject	1-5 modified Likert scale	quantitative
		3.	Measuring subject preference	1-8 preference list	quantitative
Teachers	Complex	2., 3., 4.	Semi-structured interview	15 questions about the programme	qualitative

In addition to the above, I also used triangulation to improve the validity, reliability and thoroughness of the research results.

Tracking changes in *cognitive domains*: the effectiveness of FAT teaching was assessed by students completing algebra and geometry worksheets based on the curriculum of the grade. The structure of the worksheets progressed from simpler to more complex tasks, following general didactic principles. In the areas of mathematical development, the tasks included orientation in quantitative relations (natural numbers and their relations, place value numbers, negative numbers, basic operations) and orientation and creation in space and plane (creation in space and plane, transformations, formulating differences, characterising shapes, orientation in space and plane. The knowledge measures for each grade level have been developed with the help of teachers, taking into account the NAT outcome requirements for the literacy domain.

Tracking changes in *affective domains*: in the first phase of the study, changes in affective domains were not yet investigated in Year 4. As a result of a combination of expanding literature and a broadening research horizon, it did in the second and third stages of the study. The changes were tracked using a modified Likert scale of 1-5 for liking the subject in grades 3 and 2, and a *preference* scale for liking the subject, with a number written next to the subject to indicate the opinion of the grade 3 students. The most preferred subject was numbered 1, while the least preferred subject was numbered 8. Each number could be used only once. In the third phase of the survey, the range of *data collection methods* was reduced to a minimum compared to Year 3. Following teacher consultation, the subject preference list was dropped from the data collection methods of the study due to its difficulty in interpretation. Tests in affective domains were embodied in pre- and post-tests.

Examining teachers' experiences of the intervention: in order to gain insight into teachers' opinions and experiences of FAT teaching, I used interview and semi-structured interview methods during the oral interviews. In the first stage of the research, I interviewed the class teacher, based on a set of pre-prepared questions. In the second and third phases of the research, the increasing number of teachers, the expanding knowledge of the literature, the comparability of the answers and the comparability with other studies justified the use of semi-structured interviews. The semi-structured interviews consisted of 15 questions, basically divided into two parts. Questions 1 to 8 were closely related to FAT teaching. Questions 9-15 were intended to support future research in the light of teacher suggestions and opinions. They were recruited within ten days of the completion of the programme, either through a face-to-face or telephone interview.

RESULTS

The main findings are briefly presented in the following order: cognitive domains, affective domains and interviews.

Results in cognitive domains

The composite test results for cognitive domains at grades 4 and 3 showed significant complex differences in group, time and variable factors ($F=4.369$; $p=0.0002$; $\eta 2=0.04$ and $F=2.31$; $p=0.0008$; $\eta 2=0.04$ respectively), thus confirming the effect of the intervention. In

Year 2, there were significant improvements in five variables for the experimental groups and two variables for the control groups.

Results in affective domains

The main finding in this area is that the FAT approach has shifted students' love of mathematics in a positive direction. The level of liking for the mathematics subject increased in the experimental groups in Year 3 and Year 2, while it decreased in the control groups. On the preference list, the mathematics subject improved by almost one place for the experimental group, while it moved down for the control. The use of the FAT methods supported students' engagement in the subject and reinforcement of their preference.

Results of the teacher interviews

By introducing an innovative pedagogical method, I contrasted active mathematics teaching with classical classroom teaching. I investigated their attitudes towards the methodological innovation and their enjoyment of it in the initial questions.

Four of the teachers in the five classes gave absolutely positive feedback on the new lesson plans (it was easy to motivate children; preparing for lessons was not much more work; the mini-tanments were useful; concepts were more tangible), while one reported minor difficulties (lack of space, shared lesson plans were challenging). Responses to further questions in the semi-structured interview report on changes in student behaviour and attitudes. Primarily, they report an increase in enjoyment levels, evidenced by an increase in the number of smiles from children. A key moment identified by teachers was the increased mobility in class, which provided opportunities to move away from the desks. Teachers reported increased student cooperation and support for each other during FAT lessons. Among the benefits of physically active mathematics lessons, the possibility of legitimised movement, the children's love for ladder lessons, the shift to spatial activity (from 2D to 3D), the plasticisation of decimal crossings were identified and named. The interviewees were keen to disseminate the method to other teachers. Personal experience and positive feedback from parents were behind the 'yes' of the disseminators.

TESTING THE HYPOTHESES OF THE DISSERTATION

My first hypothesis (H1) concerned interventions. I hypothesized that there would be a demonstrable positive relationship between the regular mathematics classroom FAT teaching tool and changes in subject achievement.

In a pedagogical experiment in three grades of lower secondary school, I investigated the impact of subject development by analysing changes in the results of age-appropriate knowledge measures composed of mainly algebraic and geometric tasks.

The measurement results show that there was a positive trend and a greater improvement in the overall score changes of the knowledge measures of the (experimental) groups using the ladder during the short duration of the intervention (6-10 weeks) than the control group not using the ladder. Significant improvements were detected for our experimental groups in the two-group pedagogical experiments in Year 4 and Year 2, but not for the control groups. In grade 3, we demonstrated an improvement in performance in the twice-weekly ladder use, but there was no statistically proven change in results. There were no differences in the mathematics curricula of our control and experimental groups, both strictly following the curriculum. The only difference between the groups was the pedagogical approach. Accordingly, I attribute the differences in performance observed and measured primarily to the use of the FAT teaching tool. My hypothesis H1 is thus confirmed.

My second hypothesis (H2) was related to the cognitive and affective spheres of the learners. I hypothesised that the FAT lesson would result in a positive change in the cognitive and affective spheres of the students involved in the intervention. I tested the developmental impact of the experiment in the lower grades by means of knowledge measures in the cognitive domains, compiled by the subject teachers. The written task sheets included algebraic, geometric and attention tasks. In addition to changes in the scores for each type of task, I also took into account changes in the overall scores obtained by pupils in the lower grades. The measured results suggest (see hypothesis H1) that FAT instruction implemented with the VSL3D sport/system promoted positive changes in the cognitive domains of the students involved in the intervention. A modified Likert scale was used to monitor the effects of FAT instruction on affective domains (in grades 3 and 2). The magnitude of subject attitudes was recorded before and at the end of the week-long pedagogy experiment. Examining the results, it was found that for the control groups that did not use the ladder, the change in liking of the mathematics subject was negatively predicted. There was a decrease in the measurable magnitude of liking for the subject, with a -0.04 Likert scale mean in grade 3 and a -0.21 Likert scale mean in grade 2. For the experimental groups, the attitude towards the subject shifted in a positive direction, with a calculated magnitude of +0.06 in grade 3 and +0.08 in grade 2. Teacher interviews also confirmed that children were motivated during FAT lessons. They were energized with positive feelings due to the new type of lesson delivery and methods. There was a fundamental change in the atmosphere of the lesson. The positive effects of the FAT methods are confirmed. My hypothesis H2 was confirmed.

My third hypothesis (H3) concerned intervention effects in algebraic and geometric problems. I hypothesized that performance improvements would be larger in algebraic tasks than in geometric tasks. The changes in scores on the lower-school mathematics knowledge measurement tasks were aggregated by task type. The analysis of the aggregated geometric tasks shows that in 11 tasks of this type in the three grades, statistically proven performance improvements were observed in three items, improvements in six items and only two items showed deterioration. While the analysis of the 28 algebraic tasks shows that significant improvement was identified in nine items, significant deterioration in three items, improvement and deterioration were identified in a further seven items, and no measurable change in performance was identified in two items. In the light of the results, it can be concluded that the improvement effect of FAT instruction was stronger in the geometric and spatial orientation tasks. My hypothesis H3 cannot be considered proven.

My fourth hypothesis (H4) focused on changes in the affective sphere. I hypothesized that subject attitudes and the place of mathematics on the preferential list would change in a positive direction as a result of active laddering. Results from previous studies have shown that physical activities integrated into the lesson not only induce measurable improvements in cognitive domains, but also have a positive influence on affective domains. Physically active lessons using ladders fit into the range of lessons supported by FAT devices that can increase the number of successful experiences in the classroom. The physical activity integrated into the maths lesson helped to break the monotony of a sedentary lesson, offering a playful way for primary pupils to practise the tasks of the curriculum. To monitor changes in affective domains in grades 2 and 3, a modified 1-5 Likert scale measuring liking of the subject was used. In grade 3, we used a subject preference scale with ranks 1-8, where the most preferred subject was marked by children as 1 and the least preferred subject was marked as 8. In addition, the semi-structured interviews with primary school teachers in the pilot groups were taken into account. The positive change in liking for mathematics was confirmed in hypothesis H2. The change in the score of the preference for the mathematics subject shows that the students in the control group ranked the mathematics subject with a score of 3.57 in the pre-test. In the post-measurement, the ranking value averaged 3.91, i.e. it moved away from the most preferred subject. For the experimental group, the mean value decreased from an initial 3.82 to a mean of 3.07, i.e., a ¾ improvement in the mathematics subject ranking on the preference list. Teachers reported increased classroom activity, improved mood, increased interest and, not least, children's support for each other. Overall, the enjoyment level of mathematics lessons has increased. Hypothesis H4 was confirmed.

My fifth hypothesis (H5) focused on teachers' opinions and experiences. I hypothesised that teachers would evaluate the intervention positively and explore the differentiated developmental potential of FAT teaching. For the fifth hypothesis, I base my answer on the interviews with teachers. Teacher interview responses and teacher perceptions of the success of the program are rated positively. Teacher responses argued for the usefulness of the intervention. Their prior fears that physically active lessons were noisy and distracting, and their doubts about their own competence, were in line with international research findings. To address the latter, we created recorded mini lessons. No reports of disruptive classroom behaviour were received.

They were afraid of the lack of space, too much frequency, and the lack of "pizzazz" in larger classes. In other cases, the usefulness of the intervention was argued, either in terms of increasing the enjoyment of lessons or in terms of supporting the learning content. This is confirmed by the teachers' evaluation of a pedagogical experiment based on a laddered lesson, in which the programme averaged 8.8 points on a Likert scale of 1-10. Teachers reported that the new way of teaching helped to mask individual differences and made concepts clearer to those with less mathematical ability through the use of movement. In the FAT pedagogical experiment, a consensus emerged among the teachers involved in the programme that they would like to continue using this innovative tool and its associated methods in their lessons in their subject areas. Differentiation and its various aspects emerged as an area of application, potentially creating the possibility to bring pupils and/or groups of pupils to a level of knowledge appropriate to their individual abilities and attainable. In the light of the above, hypothesis H5 is confirmed.

CONCLUSIONS - PRACTICALITY

With the novel approach of the thesis, I wanted to draw attention to the wide-ranging beneficial effects of physical activity and physical education and their potential, which can and should be put at the service of the development of learning skills of children in lower secondary school.

The dissertation shows that the FAT lesson-guided pedagogical experiment implemented using VSL3D not only influenced the improvement of student performance, but also broadened the teaching perspective of the teachers involved. It provided sufficient professional space for both classroom interaction and their development. The increased number of classroom connections seems essential for the successful implementation of future school and classroom physical activity interventions. Throughout the study, attention was paid to supporting colleagues to bridge the 'gap' between research and school practice. The research has highlighted the fact that teachers are key partners in integrating educational innovations into learning and teaching processes, and therefore the importance of providing a supportive context and structure, as well as teacher agency, is paramount (Priestley et al., 2015).

Teachers' experience and the results obtained confirmed that FAT-type lesson management can provide a number of benefits for young learners even in the short term - 6-10 weeks. During the physically active lessons, the sports ladder functioned as a competence-building tool, as it was used to practise mathematical skills in a playful way, building primarily on the use of coordination skills (balancing, spatial orientation, rhythm and kinesthesia). The ladder provided a new interpretative framework to visualise mathematical concepts in space/3D, so that they could no longer be interpreted only on paper/plane/2D. The evolution of learning outcomes speaks for itself. And the changes in children's attitudes to learning paint a promising picture in the medium and long term in terms of engagement with the subject. If a love of the subject can be fostered, it will not only have a stress-relieving effect, but can also form the basis for longer-term academic achievement.

A major advantage of the FAT tool under study is its easy adaptability and simple, user-friendly usability, whether approached from a learner or teacher perspective. After a few suitable exercises, a ladder lesson can be easily put together in a form that suits our pedagogical objectives. In small classrooms in the home, it is a real alternative to nontraditional teaching aids to support non-conventional classroom management, thanks to the adaptability of the innovative sports equipment (Lim, 2006; Van Oers, 2013).

In the light of the above, we recommend the integration and introduction of FAT methods in primary teacher education. Furthermore, the transfer of methodological knowledge from the field of psycho-motor skill development in teacher training should be made more aware. A similar approach should be adopted for the training of pre-school teachers. In the light of the results, it is recommended that sport science training should focus on the development of coordination skills and that a sensorimotor approach should be widely disseminated, highlighting the links between the senses and coordination skills.

Another major advantage of the FAT teaching tool is that it is aligned with both the National Curriculum and the framework curricula. It contains modern methods and good practices that promote interaction with other areas of education, increase the added value of physical education, and strengthen the development of inclusive and proactive thinking of pupils. NAT2020 supports a good number of the principles, so there is no regulatory obstacle to its widespread introduction in public education.

Of course, there are practical benefits to the thesis in its approach from an academic perspective. The results of the dissertation will contribute to the extension of the studies and literature demonstrating the effectiveness of FAT methods, and will also provide a basis for further areas of investigation.

Summarizing the results of the research, VSL3D sport/system/system szerintem ezt nem így hívták angolul. as an alternative FAT teaching tool offers viable solutions for the integration of physical activity into the classroom, for the introduction of physical activity into everyday practice, which can greatly support methodological innovation.

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