Eszterházy Károly University Doctoral School of Education Science

Thesis of doctoral (Ph.D.) dissertation

Modern Meteorological Knowledge and Related Behaviour Patterns in Environmental Education

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1. Research precedents

Objectively speaking, global society has become increasingly vulnerable to natural disasters. Consequently, the conscious use and adequate interpretation of weather forecasts and warnings have taken on heightened importance. While the science of weather forecast has been steadily developing, evidence shows throughout the world that the utilisation of the information provided by weather forecasts is generally not efficient enough. However, in the context of risks becoming more relevant, rapid development and ineliminable uncertainty, the members of society need to familiarise themselves with such information as well. This learning process requires, among others, the targeted expansion and specification of institutional education. In addition to the transfer of knowledge, mentalities also need to be shaped with a view to a more efficient application of meteorological information.

In Hungary *Dragovácz* and *Bódog* (1985) were the first to conduct a survey about how people interpret and use weather information. The subjects of the survey were secondary school students attending the "National Reunion of Country Trekking Students" ("Országjáró Diákok Országos Találkozója"). *Márta H. Bóna* (1989) carried out similar research on the adult population. In recent years, a survey carried out on a 500-person sample for an MSc thesis revealed that there seem to be problems with the practical application of meteorological information in everyday life on the level of knowledge, skills and attitudes among the adult population (*Petróczky*, 2015). These problems include the lack of factual knowledge, indifference, exaggerated expectations about forecasts and warnings, the incorrect interpretation of the information due to the lack of the necessary background knowledge, the lack of acquired behaviour patterns to be followed in the event of certain hazardous weather situations, and the inappropriate choice of weather information sources.

From foreign research on the subject, Stewart's scholarship must be highlighted in the first place: he introduced the notion of "weather salience" for the examination of the affinity for weather information, and developed a methodology for its measurement. With the help of this questionnaire, known as WxSQ in literature, he first assessed the affinity of the students at the University of Georgia before extending his research to the adult population of the USA *(Stewart*, 2006, 2009; *Stewart et al*., 2012). *Peachey et al.* (2013) also examined university students, but the topic of their research was a crucial issue and challenge of our days: the interpretation of probability forecasts.

While examining the use and interpretation of weather information, we should not overlook the findings of the surveys and pedagogical experiments conducted in relation to knowledge about climate change and its effects. It is common knowledge that in many cases, the increasing frequency and intensity of extreme weather incidents can be put down to climate change. In Hungary such studies and school experiments have been undertaken mostly in the workshop of Eszterházy Károly University (*Mika, Utasi & Pajtókné Tari,* 2008; *Kiss et al.*, 2011, *Pajtókné Tari et al.,* 2012; *Kiss,* 2013; *Pajtókné Tari, Mika & Kiss*, 2013; *Kiss,* 2015).

Although factual knowledge about the weather can be obtained from various weather-related technical books, popular science literature, and Internet sources, the most efficient site for the propagation of knowledge and the shaping of mentalities is the realm of institutional education.

II. Research aims

My research was motivated by the effort to enable students to acquire such knowledge in the course of school education that would help them interpret weather phenomena and weather forecasts as well as apply this information to their everyday decisions now and later in their adult lives. My aim was to put together and test a teaching material with the help of which students could acquire meteorological knowledge more efficiently than in the past. According to the curriculum based on sequential knowledge systems that are also functional as distinct and independent units, students study about meteorological knowledge within the subject of science in fifth grade and within geography in ninth grade. Therefore I examined and further developed the atmosphere- and weather-related sections of these two subjects in the course of my research.

At the beginning of my research, I asked the following questions:

1. To what extent do the chapters of science and geography textbooks discussing meteorological knowledge serve the educational and teaching goals set forth by the National Core Curriculum and the framework curricula, and the formation of a knowledge that would be applicable in everyday life?
2. What kind of new professional knowledge should be used to complete and modify the science and geography curriculum in elementary and secondary schools so that it would enhance students' understanding of the connections between weather and atmospheric processes, and weather forecast possibilities?
3. What kind of additional knowledge should be taught and what skills and competences should be specifically developed to enhance the formation of the desire to be informed, the

ability to recognise hazardous situations caused by the weather and the learning of the appropriate behaviour patterns?

These research questions had not been studied in earlier research, and I did not encounter such research either in the Hungarian or the international literature. Therefore this research is novel, and its subject is relevant because weather affects our day-to-day life significantly, and being able to adapt to it and mitigate weather-related risks are issues that concern the entire society.

III. Initial hypotheses

Upon starting my research, I formulated the following hypotheses:

- Hypothesis 1: Based on the findings of research examining people's meteorological knowledge and related information acquisition strategies as well as my first impressions as I browsed through science and geography textbooks, I hypothesise that textbooks do not discuss weather-related knowledge in appropriate depth. They fail to offer sufficient help to understand connections, become familiar with the modern instruments and methods used by meteorology, identify weather phenomena, interpret forecasts and warnings, and make the appropriate decisions in order to minimise risks.
- Hypothesis 2: Through the multi-faceted and professional teaching about atmospheric processes and by placing them into a modern and realistic context, we can help students better understand the reasons leading to the various weather incidents, see the connections between the phenomena, and thus increase the efficiency of the application of such knowledge in their everyday life.
- Hypothesis 3: Presenting the spectacular and often mysterious phenomena of the weather helps arouse students' interest in atmospheric processes.
- Hypothesis 4: The ampler and more richly illustrated discussion of this topic creates a more accurate picture in students about meteorological measurement and observation as well as the possibilities and limitations of weather forecasts and warnings.
- Hypothesis 5: By pointing out the usefulness of weather forecasts and warnings, we can achieve that students would use these pieces of information consciously in their everyday life.
- Hypothesis 6: The curricular integration of behaviour patterns to be followed in case of weather emergencies promotes the shaping of the ability to act appropriately and responsibly for ourselves and others alike.

IV. Research process, methods and tools

The strategy followed throughout the research was inductive. The tasks, methods and tools of the research consisting of several sequential phases can be summarised as follows:

- In the first phase of my research, in addition to studying the available literature on the use and interpretation of weather information as well as surveys on knowledge about climate change and its effects, and the findings of pedagogical experiments, I reviewed the fundamental pedagogical documents, i.e. the National Core Curriculum and the framework curricula, focusing on the development areas, educational aims and general culture contents in relation to meteorological knowledge.
- Next, I analysed the chapters of science and geography textbooks discussing weather-related knowledge according to the Dárdai system of criteria (*Dárdai*, 2002). In order to confirm the conclusions reached during the analysis of the textbooks, I also asked teachers using these books about their opinion with the help of a questionnaire. In our first publication on the subject, we presented the analysis of the weather-related teaching materials of the most generally used science and geography books before 2012 (*Buránszkiné & Ütőné,* 2013). After the introduction of the new National Core Curriculum in 2012 and the release of the revised textbooks, the study had to be repeated (*Buránszkiné*, 2014). Since then, the experimental textbooks of the Hungarian Institute for Educational Research and Development (OFI) have also come into use, so I considered it necessary to extend the textbook analysis to the new textbooks as well. I found several positive changes in them, both in terms of the structure of the teaching material and of didactic approach (*Buránszkiné*, 2017).
- As a next step, based on my conclusions drawn from the textbook analysis and the feedback of the teachers surveyed, I created some experimental teaching materials for fifth-grade and ninth-grade students for the meteorological topics of science and geography. As I was preparing the teaching material, besides the transfer of the knowledge set forth in the curricular requirements, I focused on presenting the phenomena from a systems perspective, pointing out the causal relationships between the atmospheric processes, recognising the weather phenomena in nature, arousing interest in information acquisition, introducing the modern instruments and methods of meteorology as well as on the recognition of weather hazards and the learning of related behaviour patterns. The teaching material prepared in

PowerPoint format contained texts, figures, animations and videos. In the discussion of the topic units, I strived to rely on a broad array of teaching/learning methods such as knowledge transfer, experimenting, observing nature, and project activities. For the development of the experimental material, I used methodological books and textbooks which facilitate teaching in a constructivist educational environment (*Leat*, 1998; *Merényi et al.,* 2005*; Farsang,* 2009*,* 2011*; Martin*, 2013; *Makádi,* 2013*; Skamp & Preston*, 2014) because in my opinion, the constructivist pedagogical approach lends itself perfectly to the teaching of weather-related knowledge. Using some ideas adopted from the available literature as well as my own, I also had a publication on this subject (*Buránszkiné*, 2016).

- The development of the teaching material was followed by the preparation and validation of the questionnaires and worksheets to be used as measuring instruments.
- The teaching material thus prepared was tested in the framework of a pedagogical experiment with the participation of six secondary schools and four elementary schools. The pilot and control groups were constituted by the parallel classes of the fifth and ninth years, the teachers being the same for both groups in the same grade. In one of the classes, the chapter on weather was taught using the experimental material while in the parallel class it was discussed according to the methodology of the textbook. The efficiency of the experimental material was measured by performance measurement and an attitude survey. In order to demonstrate changes, I used pre- and post-measurement worksheets as well as an attitude questionnaire.
- I processed the results of the questionnaires and the worksheets with the help of Excel and SPSS software. In a difference survey, I examined the differences between the results of the pre- and post-measurements and those of the control and pilot groups on a $p < 0.05$ significance level. As in most cases the total number of points did not prove to have a normal distribution, instead of the t-trial used the most frequently in pedagogical experiments, I used non parametric trials: a Wilcoxon trial in one-sample cases and a Man-Whitney trial in two-sample ones. During the statistical processing of the data, I also looked at the distribution of the performances, examining whether the new teaching material led to a more homogeneous knowledge in comparison with the traditional one.
- I published the details of the school experiment and the research outcomes in the electronic journal entitled *EDU Szakképzés és Környezetpedagógia* (*Buránszkiné,* 2017). The process of the development of the experimental teaching material is described in the publication

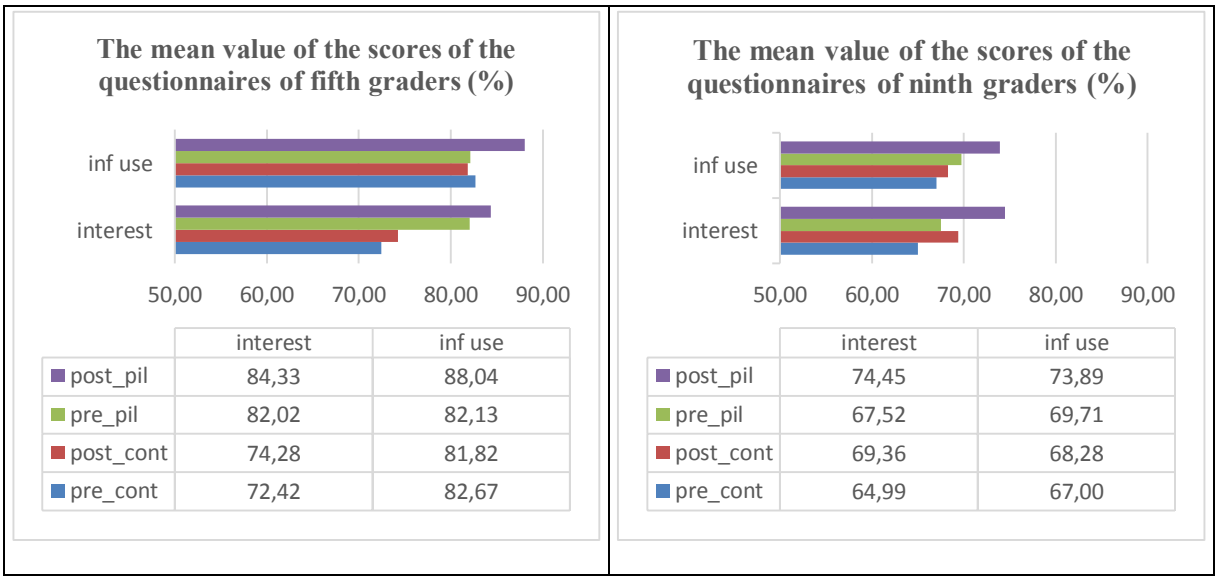
containing the research papers presented at the lecture series held at Eszterházy Károly University on the occasion of the Day of Hungarian Science (*Buránszkiné,* 2018). I discuss the possibilities to use this teaching material outside class in my paper published in the volume entitled *Környezeti nevelés és tudatformálás II* (*Buránszkiné,* 2018).

V. Discussion of the findings

I managed to justify my Hypothesis 1, which I had formulated in relation to Research Question 1, by analysing the weather-related chapters of the geography and science textbooks, and with the help of the questionnaire inquiring about the teachers' opinions.

The textbooks used in the academic year 2014/2015 do not discuss weather-related knowledge in appropriate depth. They fail to offer sufficient help to understand connections, become familiar with the modern instruments and methods used by meteorology, identify weather phenomena, interpret forecasts and warnings, and make the appropriate decisions in order to minimise risks for the individuals and their families.

The confirmation of the hypotheses formulated in connection with Research Questions 2 and 3 was done through the statistical processing of the results of the pedagogical experiment set up for testing the new teaching material. Using the attitude questionnaire, I measured the effect of the instruction on the students' level of interest and their conscious information use. The mean value of the scores is presented in Figure 1 while the findings of the significance test of the differences can be seen in Table 1.



	interest	inf use
post_pil	84,33	88,04
pre_pil	82,02	82,13
post_cont	74,28	81,82
pre_cont	72,42	82,67

	interest	inf use
post_pil	74,45	73,89
pre_pil	67,52	69,71
post_cont	69,36	68,28
pre_cont	64,99	67,00

Figure 1: The mean values of the scores achieved by the pilot and control groups in the questionnaire survey during the pre- and post-measurements

Table 1: The results of the significance test of the differences regarding the level of interest and information use

Group/Survey	5th grade		9th grade	
	Bigger score	**Is the difference significant?**	**Bigger score**	**Is the difference significant?**
Pre-measurement pilot_control group				
level of interest	pilot	yes	pilot	no
information use	control	no	pilot	no
Post-measurement pilot_control group				
level of interest	pilot	yes	pilot	yes
information use	pilot	yes	pilot	yes
Control group pre-measurement_ post-measurement				
level of interest	post	no	post	yes
information use	pre	no	post	no
Pilot group pre-measurement_ post-measurement				
level of interest	post	yes	post	yes
information use	post	yes	post	yes

With the help of a knowledge test, I measured the results achieved regarding the identification of cause and effect relationships, the application of the knowledge acquired, familiarity with the modern instruments and methods of meteorology, and the acquisition of weather hazards and related behaviour patterns. The mean values of the scores for the individual factors of the worksheets are shown in Figure 2 while the results of the significance test of the differences are presented in Table 2.

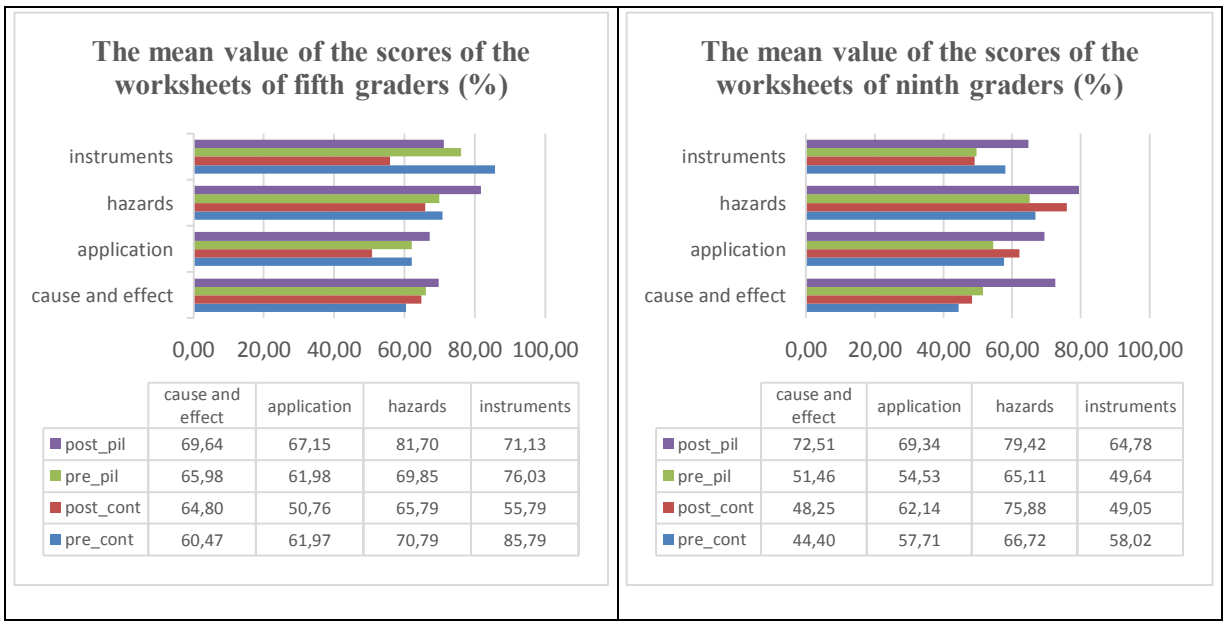


Figure 2: The mean value of the scores achieved by the pilot and control groups on the knowledge test during the pre- and post-measurements

Table 2: The results of the significance test of the differences regarding the factors measured by the knowledge test

Group/Survey	5th grade		9th grade	
	Bigger score	**Is the difference significant?**	**Bigger score**	**Is the difference significant?**
Pre-measurement pilot_control group				
cause and effect	pilot	no	pilot	yes
application	pilot	no	control	no
hazards	control	no	control	no
instruments	control	yes	control	yes
Post-measurement pilot_control group				
cause and effect	pilot	no	pilot	yes
application	pilot	yes	pilot	yes
hazards	pilot	yes	pilot	no
instruments	pilot	yes	pilot	yes
Control group pre-measurement_ post-measurement				
cause and effect	post	no	post	no
application	pre	yes	post	yes
hazards	pre	no	post	yes
instruments	pre	yes	pre	yes
Pilot group pre-measurement_ post-measurement				
cause and effect	post	no	post	yes
application	post	yes	post	yes
hazards	post	yes	post	yes
instruments	pre	yes	post	yes

The research findings justified Hypotheses 3, 5 and 6.

Presenting the spectacular and often mysterious phenomena of the weather helps arouse students' interest in atmospheric processes.

By pointing out the usefulness of weather forecasts and warnings, we can achieve that students would use these pieces of information consciously in their everyday life.

The curricular integration of behaviour patterns to be followed in case of weather emergencies promotes the shaping of the ability to act appropriately and responsibly for ourselves and others alike.

Hypotheses 2 and 4 were partly justified by the research results.

Regarding Hypothesis 2, the tasks measuring the understanding of the cause and effect relationships produced a curious result. While in fifth grade, I was unable to demonstrate the

positive effect of the experimental teaching material for this factor, a more profound explanation of the physical connections between the phenomena produced the biggest difference in score in favour of the pilot group in ninth grade. It seems probable that the scientific background knowledge of fifth graders is not sound enough to allow for the teacher to base cause and effect relationships onto it, and at this age, learning without actually understanding is prevalent.

Through the multi-faceted and professional teaching about atmospheric processes and by placing them into a modern and realistic context, we can increase the efficiency of the application of such knowledge in everyday life, and by drawing on the already existing knowledge of physics of ninth-grade students, we can also help students better understand the reasons leading to the various weather incidents, and see the connections between the phenomena.

In the case of the fifth graders, Hypothesis 4 could be confirmed only with respect to their familiarity with meteorological instruments whereas in the case of the ninth graders, it could be justified regarding their knowledge both about instruments and weather forecast.

The ampler and more richly illustrated discussion of this topic creates a more accurate picture about meteorological measurement and observation in students in general, and about the possibilities and limitations of weather forecasts and warnings in ninth graders.

The examination of the distribution of the scores achieved on the knowledge test indicated a higher performance score and a more homogeneous knowledge in the case of the ninth graders. Moreover, in both grades, the experimental teaching material boosted the performance of those who had achieved a poor or mediocre score during the pre-measurement to a much greater extent than the traditional teaching material.

VI. The practical utilisation of the research results and further directions for research

My research confirmed that the weather-related teaching material newly developed for the fifth and ninth graders is more instrumental than traditional textbooks for the understanding of the connections, becoming familiar with the modern instruments and methods of meteorology, identifying weather phenomena, interpreting forecasts and warnings, and making the appropriate decisions that would minimise risks. It generates more interest in the students for

the topic, and is more efficient in creating the desired attitude regarding the utilisation of weather information.

Having demonstrated the positive pedagogical impact of the teaching material, I have formulated two aims. My first goal is to disseminate this material as widely as possible so that teachers in other schools would also be able to use it either during their science and geography lessons or on extracurricular occasions: in clubs, at forest schools and on field trips. The other objective is to polish and improve the teaching material, elaborate certain topics in even more detail with additional diverse and interesting bits and pieces of knowledge, as well as questions, tasks, experiments and project activities facilitating the memorisation of knowledge. Regarding the first goal, part of it has already been implemented: based on the experimental teaching material prepared for the ninth grade, the "Atmosphere" chapter of the experimental OFI geography textbook for ninth graders has been revised. My objectives still include the reworking, expansion and electronic dissemination of the digital teaching material to allow for broader access and utilisation. Due to the limited number of lessons dedicated to this topic, I will concentrate on its utilisation in an extracurricular framework. An optimal solution could be the elaboration of a digital educational kit, which would include a teacher's guide, teaching aids, and a manual for teachers in addition to the material to be acquired by the students. I think that manuals are especially important, and I assume that we could achieve better results if we enriched the factual knowledge not only of students, but also of their teachers. This statement could be the starting point of further research. It would also be an interesting experiment to discuss weather-related knowledge in the framework of other school subjects (e.g. physics or chemistry).

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