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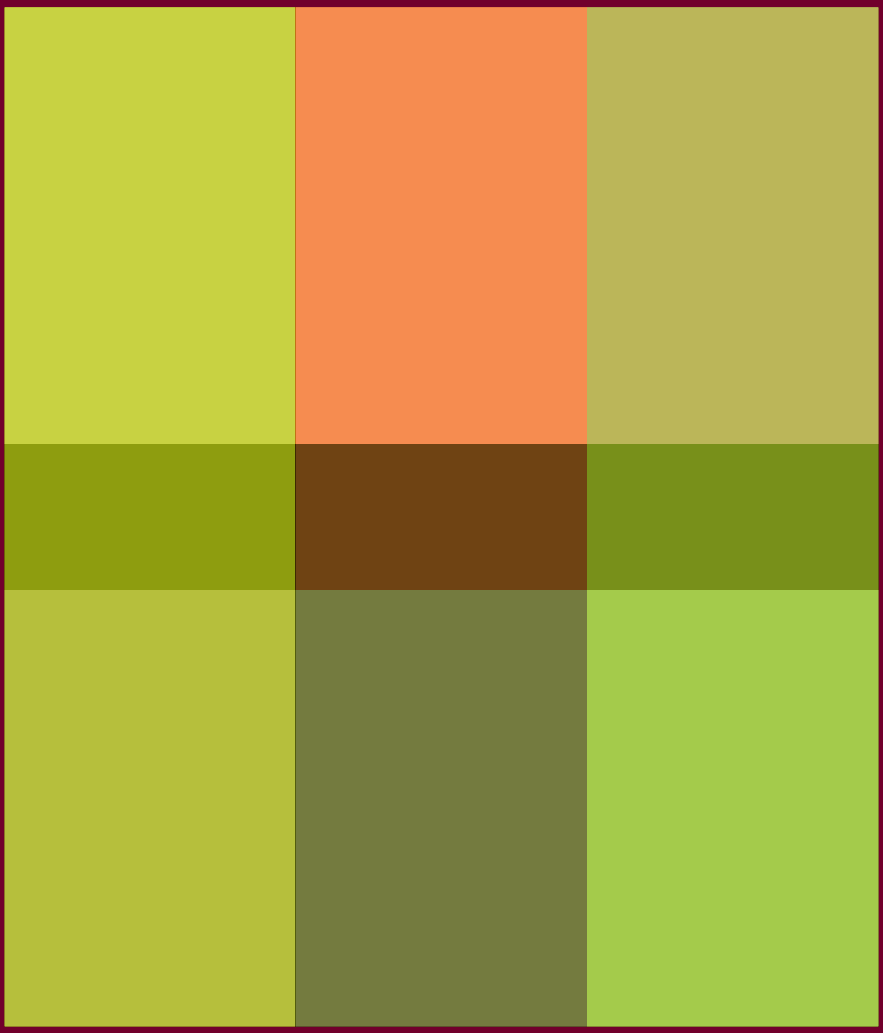

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C·E·P·S *Journal*

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The CEPS Journal is an open-access, peer-reviewed journal devoted to publishing research papers in different fields of education, including scientific.

Aims & Scope

The CEPS Journal is an international peer-reviewed journal with an international board. It publishes original empirical and theoretical studies from a wide variety of academic disciplines related to the field of Teacher Education and Educational Sciences; in particular, it will support comparative studies in the field. Regional context is stressed but the journal remains open to researchers and contributors across all European countries and worldwide. There are four issues per year. Issues are focused on specific areas but there is also space for non-focused articles and book reviews.

About the Publisher

The University of Ljubljana is one of the largest universities in the region (see www.uni-lj.si) and its Faculty of Education (see www.pef.uni-lj.si), established in 1947, has the leading role in teacher education and education sciences in Slovenia. It is well positioned in regional and European cooperation programmes in teaching and research. A publishing unit oversees the dissemination of research results and informs the interested public about new trends in the broad area of teacher education and education sciences; to date, numerous monographs and publications have been published, not just in Slovenian but also in English.

In 2001, the Centre for Educational Policy Studies (CEPS; see http://ceps.pef.uni-lj.si) was established within the Faculty of Education to build upon experience acquired in the broad reform of the national educational system during the period of social transition in the 1990s, to upgrade expertise and to strengthen international cooperation. CEPS has established a number of fruitful contacts, both in the region – particularly with similar institutions in the countries of the Western Balkans – and with interested partners in EU member states and worldwide.

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Revija Centra za študij edukacijskih strategij je mednarodno recenzirana revija z mednarodnim uredniškim odborom in s prostim dostopom. Namenjena je objavljanju člankov s področja izobraževanja učiteljev in edukacijskih ved.

Cilji in namen

Revija je namenjena obravnavanju naslednjih področij: poučevanje, učenje, vzgoja in izobraževanje, socialna pedagogika, specialna in rehabilitacijska pedagogika, predšolska pedagogika, edukacijske politike, supervizija, poučevanje slovenskega jezika in književnosti, poučevanje matematike, računalništva, naravoslovja in tehnike, poučevanje družboslovja in humanistike, poučevanje na področju umetnosti, visokošolsko izobraževanje in izobraževanje odraslih. Poseben poudarek bo namenjen izobraževanju učiteljev in spodbujanju njihovega profesionalnega razvoja.

V reviji so objavljeni znanstveni prispevki, in sicer teoretični prispevki in prispevki, v katerih so predstavljeni rezultati kvantitavnih in kvalitativnih empiričnih raziskav. Še posebej poudarjen je pomen komparativnih raziskav.

Revija izide štirikrat letno. Številke so tematsko opredeljene, v njih pa je prostor tudi za netematske prispevke in predstavitve ter recenzije novih publikacij.

The publication of the CEPS Journal in 2017 and 2018 is co-financed by the Slovenian Research Agency within the framework of the Public Tender for the Co-Financing of the Publication of Domestic Scientific Periodicals.

Izdajanje revije v letih 2017 in 2018 sofinancira Javna agencija za raziskovalno dejavnost Republike Slovenije v okviru Javnega razpisa za sofinanciranje izdajanja domačih znanstvenih periodičnih publikacij.

Contents

Varia

Interview

Reviews

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Editorial

Experiments in Physics Teaching and Learning

The first issue of volume eight consists of four parts. In the first part, there are five papers related to the focus topic of this issue: experiments in physics teaching and learning. The second part includes two Varia papers. In the third part, there is an interview with Prof. Michael W. Apple, one of the distinguished editorial board members of the present journal and a respected researcher in the field of education, while the fourth part consists of two book reviews, one of which is related to the focus topic of this issue.

The present issue focuses on experiments, which play an important role in physics teaching and learning. Numerous studies have demonstrated the positive effects of experiments on physics learning. Experiments are a powerful tool for visualising physics phenomena. They provide a starting point in the construction of knowledge, so it is important to use them in the classroom. It is well known, however, that experiments in the classroom are mostly based on demonstrations and are not performed often enough by the students themselves, even though it has been established that by experimenting students learn how to accurately observe, measure, record measurements, compare, order, state and test hypotheses, discuss and interpret results, etc. These competences are transferable to other science fields, as well. Experimental work influences skills, concept development and cognition, understanding of the nature of science, and attitudes towards science.

If we want teachers to include experiments in teaching physics, they have to be properly trained. The rich theoretical part of the article by Claudia Haagen-Schützenhöfer and Birgit Joham entitled *Professionalising Physics Teachers in Doing Experimental Work* presents the didactical perspective of experiments, the importance of experimental work in the classroom, and ways to promote learning about science and, finally, doing science. In the empirical part, the authors present a study examining teachers' beliefs about the function of experiments in science teaching and their meaningful implementation in the science classroom.

Preservice teachers have to learn to design, carry out, analyse and evaluate experiments on different topics covering the learning objectives from the curricula on different levels of education. Astronomy is an interesting topic for students of different age groups, but experiments in this field are complex. In the paper *Determination of the Size and Depth of Craters on the Moon*, Vladimir Grubelnik, Marko Marhl and Robert Repnik present an example of observation of the Moon undertaken without professional astronomic equipment, as well as

analysis of photographs using simple calculations that lead to specific results: the lateral size and depth of craters. The experiment was carried out by a group of preservice primary school teachers during the elective subject Astronomy and then evaluated. The results indirectly show that it is appropriate to implement the presented activity in the secondary school physics classroom.

University faculties often enable teachers to bring their students to the faculty to carry out a number of simple and complex experiments. The first example of such activities is presented in the paper by Marie Snětinová, Petr Kácovský and Jana Machalická entitled *Hands-On Experiments in the Interactive Physics Laboratory: Students' Intrinsic Motivation and Understanding*. The authors discuss experiments in different forms as a tool for increasing motivation. Two types of experiments are presented: so-called projects, which their faculty offers to upper secondary students, giving students an opportunity to undertake hands-on experimental work in the Interactive Physics Laboratory; and physics demonstration shows. In the empirical part of the article, the authors focus on assessing student feedback about their immediate attitudes towards these two projects, with an emphasis on motivation. In the paper's conclusion, the authors highlight the fact that, while experimenting in the Interactive Physics Laboratory, students feel the need to invest significantly more effort and experience more tension than when watching demonstrations. However, students do not see a difference in the usefulness of undertaking practical work and watching demonstrations, despite finding the former more demanding.

The second example of collaboration between a university faculty and secondary schools in carrying out experiments is presented in the paper *Let's Repair the Broken Galileo Thermometer* by Marián Kireš. The author gives a detailed account of the experiment and the research. The activity for students includes an experimental problem about repairing a broken thermometer using tap water instead of ethanol. The students' understanding of the physics behind the experiment was evaluated and self-assessment was administered. Most of the students reported that they learned how a Galileo thermometer works. The author demonstrates the advantages of experimenting in science centres of this kind. At the same time, however, he points out certain issues with teacher education, and with the available support in methods and working materials.

The last paper in this focus issue is written by Robert Repnik and Milan Ambrožič and is entitled *Practical School Experiments with the Centre of Mass of Bodies*. It consists of a presentation of experiments for 8th and 9th grade students of Slovenian primary schools, and an evaluation of the experiments with four different groups of students. The research findings suggest that the implementation of group experiments about the centre of mass was motivating

for all four groups of students. In addition to the knowledge gained, the authors identified satisfactory motor skills in individual students working in groups and good geometrical reasoning.

Another feature of the present issue is an interview with Prof. Michael W. Apple, prepared for publication by Janez Krek. Prof. Apple's most important monographs include *Ideology and Curriculum* and *Official Knowledge*, which are included on the international list of the most important books of the twentieth century in the field of educational science. At the same time, Prof. Apple is ranked among the fifty most influential contemporary authors in this field. In 2016, he received an honorary doctorate from the University of Ljubljana. To honour this event, we are publishing an extensive interview with Prof. Apple.

The Varia section includes two contributions. The first, *Taxonomy of Teaching Methods and Teaching Forms for Youth in Non-Formal Education in the National Youth Council of Slovenia* by Vesna Miloševič Zupančič, presents non-formal education in youth work, emphasising the central role of experiential learning and learning in groups. The author discusses the teaching forms and methods found in non-formal education for young people in youth councils on a national level in Slovenia.

The second paper in the Varia section was written by Seyyed Hatam Tamimi Sa'd and Fereshte Rajabi is entitled *Teaching and Learning Vocabulary: What English Language Learners Perceive to Be Effective and Ineffective Strategies*. The authors present the results of research with students exploring Iranian English language learners' vocabulary learning strategies and perceptions of vocabulary learning, as well as Iranian English language teachers' vocabulary teaching strategies.

This issue of CEPS Journal also includes two book reviews. Neja Benedetič's review of the book *Multiple Representations in Physics Education* (Volume 10 from the series *Models and Modelling in Science Education*), edited by David F. Treagust, Reinders Duit and Hans E. Fischer (Cham: Springer, 2017, 322 pp., ISBN 978-3-319-58912-1), presents a recent publication in the series of Springer monographs covering different aspects of the use of multiple representation in science education. It is shown that different representations allow students to be introduced to a physics concept from different perspectives, combining graphs, text, mathematical formulas, schemes, gestures, etc. into a whole. However, the authors also point out that the teacher has a crucial role in using multiple representations and enabling students to establish a correlation between different representations.

The book *Teacher Education for Multilingual and Multicultural Settings*, edited by Elgrid Messner, Daniela Worek and Mojca Peček (Graz: Leykam,

2016; 199 pp.: ISBN 978-3-7011-0361-4), reviewed here by Karmen Mlinar, provides an interesting and systematic insight into the theoretical and practical issues of European multicultural and multilingual settings, as well as offering a series of proposals for improving teacher education programmes.

The new issue of the CEPS Journal brings a variety of papers from various education research fields, reporting and discussing several open research questions. We believe that the information available in this issue will encourage reflection on the research problems addressed and raise new research ideas.

Jerneja Pavlin

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Professionalising Physics Teachers in Doing Experimental Work

Claudia Haagen-Schützenhöfer*[1] and Birgit Joham[2]

It is commonly agreed that experiments play a central role in teaching and learning physics. Recently, Inquiry-Based Learning (IBL) has been introduced into science teaching in many countries, thus giving another boost for experiments. From a didactical point of view, experiments can serve a number of different goals in teaching and learning physics. First of all, experiments can support learners in understanding some of the central concepts of physics. Besides this function of "learning physics", empirical evidence shows that experimental work in general has a high potential for promoting "learning about science" and finally "doing science". Promoting aspects of how science works has become important, as the ideas of scientific literacy and competence orientation have been established as central educational goals in many national education systems. However, empirical studies show that the reality in schools does not match these expectations. Conventional physics classes still aim only at the mastery of content, and experiments that cognitively activate students and address issues related to the Nature of Science (NOS) have not been implemented extensively. The reasons for this can be found in teachers' attitudes and beliefs, as well as in their PCK concerning experiments and scientific knowledge production. In past decades in Austria, teacher education did not focus a great deal on the didactical aspects of experiments or their integration into physics classes in order to promote aspects of scientific literacy and competence orientation. Furthermore, there is a lack of high quality continuing professional development courses that promote the concepts of Inquiry-Based Learning (IBL) in combination with relevant ideas of NOS. The present study examines inservice teachers' beliefs about the function of experiments in science teaching and their meaningful integration into science classes. In the form of case studies, we follow the professional development of teachers in this field during continuing teacher training.

Keywords: experiments in science teaching, continuous professional development course, Inquiry-Based Learning

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Profesionalizacija učiteljev fizike v izvajanju eksperimentalnega dela

Claudia Haagen-Schützenhöfer in Birgit Joham

Pogosto se strinjamo, da eksperimenti igrajo osrednjo vlogo v poučevanju in učenju fizike. Pred kratkim so učenje z raziskovanjem v veliko državah vpeljali v poučevanje naravoslovja, kar je dalo eksperimentiranju nov zagon. Z didaktičnega vidika lahko poskusi služijo vrsti različnih ciljev v poučevanju in učenju fizike. Prvič, poskusi lahko podpirajo učence pri razumevanju osrednjih fizikalnih konceptov. Poleg te funkcije »učenja fizike« empirični podatki kažejo, da ima eksperimentalno delo na splošno visok potencial za promocijo »učenja o naravoslovju« in ne nazadnje za »izvajanje naravoslovja«. Promocija tega, kako deluje znanost, je postala pomembna, saj je ideja naravoslovne pismenosti in razvoja naravoslovnih kompetenc postala osrednji izobraževalni cilj v veliko nacionalnih izobraževalnih sistemih. Empirične raziskave pa kažejo, da se realnost v šolah ne sklada s tem. Konvencionalni pouk fizike še vedno temelji na obvladovanju učne vsebine, medtem ko poskusi, ki kognitivno aktivirajo učence in naslavljajo zadeve, povezane z naravo naravoslovja, še niso pogosto implementirani. Razloge za to lahko najdemo v stališčih in prepričanjih učiteljev pa tudi v njihovem pedagoško vsebinskem znanju, ki vključuje poskuse in naravoslovno znanje. V zadnjih desetletjih se izobraževanje učiteljev v Avstriji ni osredinjalo na didaktične vidike poskusov ali njihovo vključevanje v pouk fizike z namenom promocije naravoslovne pismenosti in naravoslovnih kompetenc. Še več, gre za pomanjkanje visokokakovostnih programov za stalno strokovno spopolnjevanje učiteljev, ki promovirajo učenje z raziskovanjem v kombinaciji z relevantnimi idejami narave naravoslovja. Ta raziskava preučuje prepričanja učiteljev o vlogi poskusov v poučevanju naravoslovja in njihovo smiselno integracijo v pouk fizike. V obliki študije primera sledimo profesionalnemu razvoju učiteljev na področju stalnega strokovnega spopolnjevanja.

Ključne besede: poskusi v poučevanju naravoslovja, programi za stalno strokovno spopolnjevanje, učenje z raziskovanjem

Introduction: Motivation and Starting Point

Experiments and practical work play a central role in science education. In general, both teachers and students have a very positive attitude towards practical work: they "like doing experiments". The reasons and aims of the two groups are, however, different, as are the perspectives about what can be achieved in terms of affective and cognitive student variables. While, from a science education perspective, experiments can contribute to a variety of facets of science learning, they are frequently implemented only for a limited number of aims in everyday science classes.

A new focus on experiments has been introduced by Inquiry-Based Learning (IBL), which has become very popular in the last decade. In Austria, many engaged teachers are implementing IBL environments in their classes. In addition, at schools, the number of newly established science labs that are informed by the idea of IBL is growing at all age levels. At the same time, it is known that preservice training in Austria generally does not put a lot of effort into achieving a differentiated view of the use of experiments in science classes. The belief that experiments, irrespective of how they are implemented in learning environments, facilitate understanding of subject matter and raise levels of interest is very common among science teachers (Haagen & Mayer, 2015). As far as IBL is concerned, this method is only now being implemented in science teacher education in Austria.

In contrast to the situation on the level of teacher education, national standards have been designed on the level of students' learning outcomes, and the idea of experimental work and inquiry has been introduced into our national competence models for secondary science education. There is therefore a clear gap between what teachers learn during their preservice training and the requirements of the national competence models for secondary education in science.

The continuous profession development programme "Competences in Mathematics and Science Education" (CMSE) is one of several actions taken by the Ministry of Education to support teachers in adapting their teaching to the requirements of the national standards.

The present paper provides an insight into the development of science teachers' beliefs about the implementation of Inquiry-Based Learning and practical work during their participation in CSME.

Standardisation in Science – A New Impetus for Experimental Work

Like in many other European countries, Austria implemented national standards and competence models after achieving poor results in PISA and TIMSS. The medium-term aim is to improve the quality of teaching and learning by shifting instructional practices from an input to an output orientation, and from a transmissive view of teaching to a constructive one.

The Austrian education system is organised into a primary level (four years), a lower secondary level (four years) and an upper secondary level, which ends with A-levels (four or five years, depending on the school type). In addition, there are other types of upper secondary education that do not end with A-levels and thus do not qualify students for direct access to university. As far as science instruction is concerned, the subjects Biology, Chemistry and Physics are taught separately in Austrian secondary schools. In primary schools, we have the subject "Sachunterricht" which combines science and humanities such as local history and geography, and social learning.

In general, competence models for all subjects were developed for year 8 and later year 12 (Haagen & Hopf, 2012; Weiglhofer, 2008). For science subjects, a common model was developed based on the construct of scientific literacy used in the PISA 2006 framework (Bybee, McCrae, & Laurie, 2009), as well as on existing competence models of other countries. The models for the subjects Biology, Chemistry and Physics (see Fig. 1) differ only on the subject matter dimension, whereas competence domains and complexity levels are identical. On the level of primary education, so far, standards have only been implemented for the core subjects Mathematics and German.

The Austrian competence model for Science year 8 (see Fig. 1), consists of three dimensions (axes): content, complexity and competence domains. The competence domains are subdivided into three facets, reflecting the core ideas of scientific literacy:

- **Knowledge** meaning "Scientific knowledge and use of that knowledge […] to acquire new knowledge [and] to explain scientific phenomenon".
- **Science Methods** as "understanding of the characteristic features of science as a form of human knowledge and enquiry" as well as the ability "to identify [scientific] questions" and answer them with the help of inquiry.
- **Judgement** describing "[the] willingness to engage in science-related issues, and with the ideas of science, as a constructive, concerned, and reflective citizen to draw evidence-based conclusions about science-related issues" (OECD, 2006, in Bybee et al., 2009)

More details concerning the Austrian competence model can be found in Haagen et al. (2012) and Weiglhofer (2008).

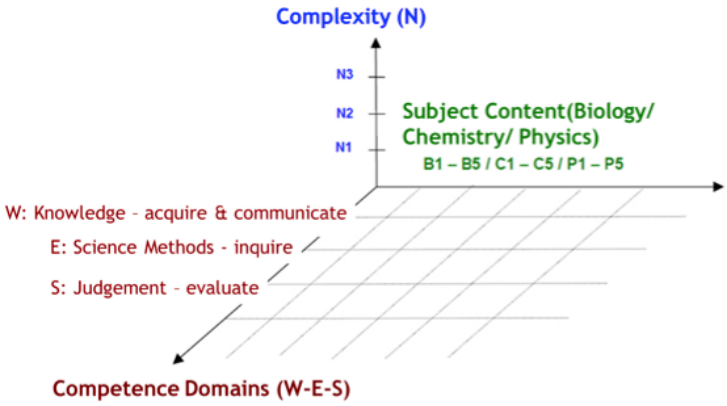

Figure 1. The Austrian competence model for Science, year 8.

Inservice Teacher Professionalisation in Austria

In Austria, inservice teacher training is not compulsory, so only one third of teachers attend trainings on a regular basis, while one third attend occasionally and one third do not attend training courses at all. What makes the situation even worse is that typical inservice trainings are very short – lasting for half a day or a day – and mostly focus on subject matter only. According to numerous research findings, effective professionalisation means to change teaching practices. Such a change is more likely to be achieved in programmes that enable activities of longer duration, that integrate subject matter, pedagogy and teaching strategies, and that include practice experiences that can be reflected on (cf. Garet et al., 2001).

Competences in Mathematics and Science Education (CMSE) is a national Continuous Professional Development Programme (CPD) that supports science and mathematics teachers from different school types in implementing teaching innovations linked to the introduction of subject-specific competences and standards in the Austrian education system.

CMSE is one of five thematic teacher professionalisation programmes within the IMST framework (Innovations in Mathematics, Science and Technology Teaching), which is another initiative launched by the Ministry of Education in 2010, after the PISA shock. The core idea of CMSE is to simultaneously intervene on the level of the teacher and the student. For one school year,

teachers work together with teacher trainers and science education researchers, who help them to address the concept of subject-specific competences in their teaching (Langer, Mathelitsch, & Rechberger, 2014).

The framework of CMSE was designed to initiate professional learning communities among the participating teachers. The aim is to support them to shift their teaching practice from input orientation to output orientation by integrating the concept of subject-specific competencies in their instructional practice (Haagen-Schützenhöfer et al., 2015). A main focus is the integration of experimental work.

Theoretical Framework

Research on Experiments and Practical Work in Science Teaching and Learning

It is undisputed that experiments are an essential part of science teaching and learning. Their contribution can be seen on at least three levels, as summarised by Hodson (2014): learning science, learning about science, and doing science.

Existing research results regarding the effectiveness of practical work and experiments in science teaching are heterogeneous: they do not confirm that experiments generally enhance the quality and effectiveness of science teaching (Lunetta, Hofstein, & Clough, 2007; Singer, Hilton, & Schweingruber, 2006). Research shows that, in many cases, there is a significant conflict between the aims teachers attribute to the implementation of experiments and the way in which experiments are implemented in science classes. According to the results of America's Lab Report (2005), the most prominent motives for integrating practical work and experiments into science instruction are:

- enhancing mastery of subject matter;
- developing scientific reasoning;
- understanding the complexity and ambiguity of empirical work;
- developing practical skills;
- understanding the nature of science;
- cultivating interest in science and interest in learning science; and
- developing teamwork abilities (Singer et al., 2006, p. 3).

This list is long and undoubtedly incomplete; nevertheless, the motives followed in everyday school reality are usually very limited and centred on the mastery of subject matter. Even though teachers intend to attain all of the

desirable goals summarised by Singer et al. (2006), data indicate (Lunetta et al., 2007; Singer et al., 2006) that they are not successful in providing appropriate practical experiences with the kind of learning environments currently in use.

Typical learning environments involve students following rigid procedures, but fail to integrate reflection or discussion (Lunetta et al., 2007; Maltese, Tai, & Sadler, 2010; Millar & Abrahams, 2009). Frequently, practical activities are used to verify or apply rules that are already part of instruction. In addition, they tend to be quite "tightly constrained" ("cookbook" or "recipe following" practical tasks) (Millar & Abrahams, 2009, p. 62), mainly focusing on procedures.

The focus of practical work is "manipulating equipment [rather than] manipulating ideas" (Hofstein & Lunetta, 2004, p. 39). This supports the development of manipulation abilities instead of establishing solid scientific concepts. Students are trained to aim at task completion as a major goal, while reflective processes are neglected. One reason seems to be that reflective phases are frequently regarded as too time consuming. In addition, some papers (Hart, Mulhall, Berry, Loughran, & Gunstone, 2000) report that tasks are rather complex and may result in a cognitive overflow, as students have to perform numerous tasks simultaneously. Another problem area identified by several authors (Lunetta et al., 2007; Singer et al., 2006) is the lack of integration of practical activities into general instruction. In many cases, hardly any relationship is established between the experiment carried out and its theoretical background. Consequently, students lack the appropriate conceptual frameworks that help them to adequately integrate the experiences acquired during practical work (Driver, 1983).

Research data show this clash between the intended goals and the general reality of practical work. A survey of the existing research (Lunetta et al., 2007) on practical work yields a variety of outcomes. However, widespread beliefs that practical activities automatically improve student achievement – especially the mastery of subject matter – cannot be supported empirically. Americas' Lab Report concludes that "Laboratory experiences have the potential to help students […], [but] [t]he potential is not being realized today" (Singer et al., 2006, p. 9).

The idea of IBL is seen as a way out of this unsatisfactory situation. It may help to shift the focus from a hands-on attitude aimed at task completion and manipulating equipment, to a minds-on attitude. The method of IBL and relevant research results will be discussed in the following section.

Inquiry-Based Learning (IBL): Models and Research Results

As in many other countries, Inquiry-Based Learning has become a major trend in Austria in recent years. However, IBL is defined in different ways,

and it can barely be separated from other open methods of instruction (Minner et al., 2010). In addition, there is a second dimension that is independent of normative definitions but influences instruction: how teachers interpret the idea of IBL on a personal level and, consequently, how IBL is implemented in the classroom depending on this individual perspective of the teacher.

For our work, we concentrated on the essential features extracted from the definitions of IBL used in NRC 2000 and NRC 1996 (National Research Council, 1996; National Research Council (NRC), 2000).

Characteristic of IBL scenarios is that students:

- are "engaged by scientifically oriented questions;
- […] give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions;
- […] formulate explanations from evidence to address scientifically oriented questions;
- […] evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding;
- […] communicate and justify their proposed explanations" (cited from: Pathway UK 2013).

These features of IBL are well matched by the competence facets defined in the Austrian competence model for secondary science, as discussed above.

Within the method of Inquiry-Based Learning, a number of subvarieties can be identified. For the professionalising processes, we focus mainly on the dimension of openness. This aspect is well differentiated in the model of Blanchard et al. (2010), who define levels of IBL based on the distribution of responsibilities between teachers and students during the three phases of the IBL process:

	Source of the question	Data collection methods	Interpretation of results
Level 0: verification	teacher	teacher	teacher
Level 1: structured	teacher	teacher	student
Level 2: guided	teacher	student	student
Level 3: open	student	student	student

Figure 2. Levels of Inquiry-Based Learning (Blanchard et al., 2010).

What distinguishes IBL as defined by Blanchard et al. (2010) from mere

exploration is that a concrete and researchable question is always the starting point of the practical student activity. Data is systematically collected and the methods of data collection are aligned to the initial questions. Consequently, this model of IBL covers all goal-oriented and result-targeted experimental student activities. Mere exploration without a defined knowledge interest (question), as well as experimental demonstrations of phenomena (which usually lack data collection methods), are excluded from this definition. Blanchard's model of IBL therefore fits our needs well, as it represents a large variety of student activities that support the development of experimental competences as defined in the Austrian competence model for secondary science. The levels of Inquiry-Based Learning represent a good basis for differentiating experimental student activities. In addition, they can support teachers in structuring experimental activities according to students' pre-knowledge and skills.

When we shift our focus to the output side of IBL in terms of learning processes, empirical evidence is, however, heterogeneous. One reason may be that a wide range of activities are labelled as IBL, which, of course, has a negative effect on comparability. A common point of many studies seems to be that the level of guidance, especially when first commencing IBL, is crucial for the effectiveness of student learning and retention (Hattie, 2013; Kirschner, Sweller, & Clark, 2006; Minner et al., 2010). A slow progression from close guidance to more open scenarios seems to be advisable. In addition, a basic but solid knowledge base of the subject matter and experimental skills are necessary for students to be able to engage cognitively in more open forms of inquiry without being overtaxed. As reasons for this, Kirschner et al. (2006) mention "expert–novice differences, and cognitive load".

As it is undisputed that students need to develop certain abilities before they are able to carry out experimental work in the form of open inquiry, in the present paper we focus, inter alia, on this issue in our evaluation of the CPD course.

Design and Methods

Participants in CMSE – The Sample

CMSE participants represent a selected sample. It can therefore be assumed that they belong to the more active, innovative and informed group of teachers, as they had to apply for the CMSE programme by submitting a proposal in which they outlined a school project aimed at implementing a teaching innovation related to subject-specific competences. Their submissions were

reviewed by external education experts and by CMSE staff. Only 20 projects are accepted for the programme each year, while the number of applications is typically around 45.

The sample of our study consists of a total of 39 teachers who were selected for the CMSE programme in the 2015/16 and 2016/17 school years. The participants of CMSE teach science subjects and mathematics at different types of schools and at different age levels, from primary to upper secondary.

Our sample of 39 teachers consists of two cohorts: one participated in CMSE in the 2015/16 school year, and the other in the 2016/17 school year. The 2015 cohort consists of 20 teachers and the 2016 cohort of 19 teachers. Out of the full sample (N = 39), 77% of the teachers are female and 23% male. Some 36% of the participants are primary teachers, who teach children aged between 6 and 10 years, while 64% of the sample are secondary teachers who teach students aged between 10 and 19 years.

On entering CMSE, the majority of the teachers (39%) had more than 10 years of teaching experience, 37% had between 5 and 10 years of teaching experience, and 24% had less than 5 years of teaching experience.

Research Questions

Our guiding research questions can be summarised as:

- RQ 1: What beliefs do the inservice teachers of the CMSE programme have regarding experimental work and IBL in general when they enter CMSE?
- RQ 2: Do the inservice teachers of the CMSE programme categorise their school projects as Inquiry-Based Learning when they enter CSME?
- RQ 3: Does their view about their previous categorisation change during their participation in CSME?
- RQ 4: What beliefs do the inservice teachers of the CMSE programme have about the Nature of Science aspects of Inquiry at the end of the programme?
- RQ 5: What beliefs do the inservice teachers of the CMSE programme have about the characteristics of effective experimental work and Inquiry-Based Learning at the end of the programme?

Interventions – The CPD Programme CMSE

The CMSE programme lasts for one year and supports 20 school projects. After succeeding in the application phase for the programme, all CMSE

participants meet for the first time at the start-up workshop (cf. Fig. 3) at the beginning of the school year. The aim of this start-up is to make participants familiar with the ideas of competence orientation and to provide them with new impulses for their projects. In the more general part, we treat organisational issues concerning project management, followed by inputs on subject-specific competences and practical work with a focus on Inquiry-Based Learning. CMSE team members then work with the participants on their individual project aims, fine-tuning them and deducing a first rough set of interventions and evaluation strategies.

The second day of the start-up is dedicated to the formation of focus groups (FG), which are proposed by the CMSE team. Each focus group consists of four to five participants and is coached by two coaches. In the focus group, each participant presents his/her current working version of the project, focusing on project aims, corresponding instructional measures and initial ideas about evaluation. Within this session, the participants get feedback and advice from the focus group coaches and the other participants.

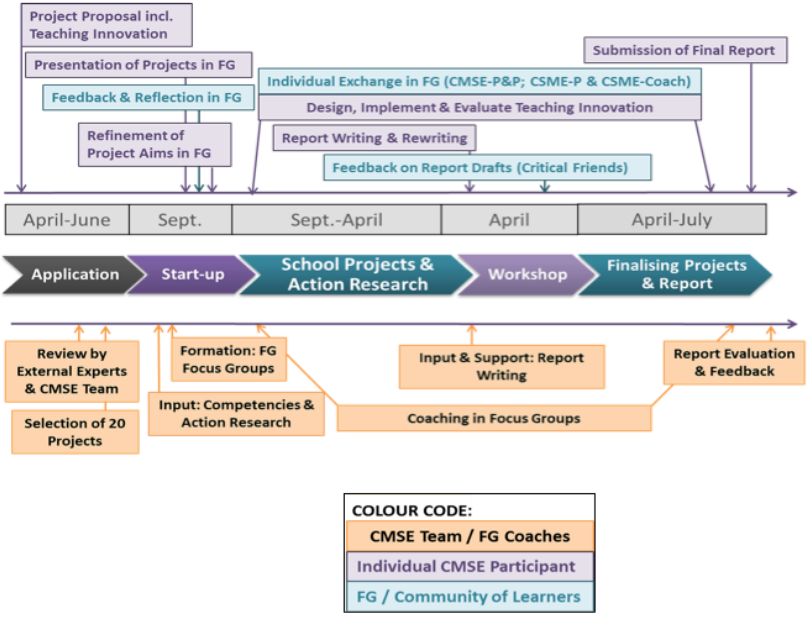

Figure 3. Intervention – the format of the professional development programme CMSE (cf. Haagen et al., 2017).

As a tool for experimental tasks, we introduce the spider-web model by Schecker et al. (2013), as shown in Figure 4. The axes of the spider-web represent

different experimental competence facets that students should develop: inquiry competences (e.g., develop questions, hypothesise) and experimental skills. The experimental skills mirror the sub-facets of experimental processes, which are typically divided into three phases of experimenting: preparation (e.g., planning experimental procedures), performance (e.g., setting up the apparatus) and evaluation (e.g., interpreting results) (Schreiber et al., 2016).

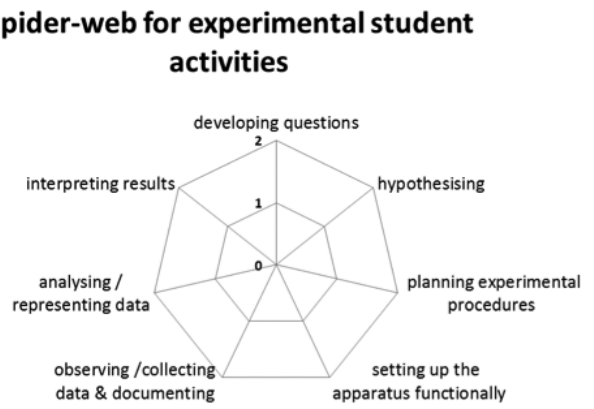

Figure 4. The Spider-Web tool for experimental student activities, adapted from Schecker et al. (2013). The scale can be used to assess an experimental task (0: not part of the task, 1: part of the task but not emphasised, 2: focus of the task). It can also be used to assess student competences (0: competence facet not shown, 1: competence partly shown, 2: competence shown to a high degree).

The spider-web can be used for different purposes. It can help to analyse and/or plan experimental tasks, but it can also be used for assessing students' experimental competences. Finally, as a self-assessment tool, it can support students in judging their own experimental competences.

In our CPD programme, the spider-web is intended to help participants to analyse their projects and identify possible shortcomings related to certain experimental competence facets. In addition, they are encouraged to use the spider-web as a basis for the design of their own learning environments. Another important step in the start-up workshop is the didactical analysis of the projects. In their focus groups, the participants work on the alignment of goals, intended learning processes and the design of appropriate interventions.

After the start-up workshop, the teachers are supported by their focus groups in the implementation of their project. The focus group functions as a "critical friend", with members supporting each other with project

implementation and reflection work. The focus groups operate in different modes: there are interim face-to-face meetings, materials and interim reports are exchanged or participants visit each other in their schools.

The final phase of the CMSE year is dedicated to the project report (see. Fig. 2), which is more or less a portfolio portraying the evolution of the innovative project. It describes the project starting from the teacher's motivation, the aims pursued by the innovative school project, the learning objectives on the level of students, and the interventions carried out, as well as the design of the evaluation and its results. The process of writing the report is supported by the implementation of various scaffolding strategies during the project year. The start-up workshop is, for example, devoted to generating the first part of the report, which specifies the intended learning outcomes. From these learning outcomes, interventions and evaluation strategies are deduced. Each of these steps is documented during the individual phases of the project. CMSE participants are also supported in finalising the project report, meeting with their coaches for three days in April. There, the participants get specific input on data analysis and academic writing. However, most of the time of this workshop is dedicated to individual counselling and support. At this stage, professional communities play a crucial role. Participants support each other by reading their drafts and giving feedback as critical friends. Within this process, the intended goals are contrasted with the evaluation results. Thus, the participants get an opportunity to reflect on the output of the project and their individual teaching practice, again with the input and help of their colleagues and coaches.

Evaluation

The evaluation of the professionalisation processes with a focus on experimental work and Inquiry-Based Learning was conducted with a pre-post design that uses two different data sources: written documents produced in the course of the project by the teachers, and answers gathered by questionnaires (see Fig. 5). Data of each type is collected before the actual implementation of the school projects and after the completion of the projects: the project proposals produced by the teachers for their application for CMSE, and the final project report.

The application form for the CMSE programme contains sections concerning the participants' innovative projects and, among other issues, focuses on their intended goals related to students' subject-specific competences, students' learning outcomes, instructional interventions, and evaluation strategies. At the end of the project year, a final project report is required in order to

complete the CMSE programme. This report develops during the project year and serves also as tool for structuring and reflecting on the participants' professionalisation process. The structure given in the template of the final report corresponds partly to the structure of the application form. Thus, it is possible to extract data from one document that is produced before the start of the project – the project proposal – and from one that portrays the final development stage at the end of the project – the final project report (see Fig. 5). The following points are included in the application and/or the final report, and serve as a data corpus for our analysis:

- analysis of the status quo of the individual teaching and possible areas for improvement/innovation (application & final report);
- goals on the level of students and teachers, in order to improve the issues identified in the first point (application & final report);
- development of innovative interventions to achieve the set goals (application & final report);
- implementation of the teaching innovation (final report);
- evaluation of the teaching innovation (final report).

In order to place special emphasis on practical work and Inquiry-Based Learning, questionnaires were used as a second data source on the level of teacher professionalisation. They were administered at the start-up meeting and in a similar form at the end of the project year (see Fig. 5). The questionnaires contained open questions as well as multiple choice questions on the following topics:

- students' competences in the context of science education;
- the Austrian competence model for science subjects;
- competence domains in science according to the Austrian competence model;
- characteristics of Inquiry-Based Learning in science subjects;
- levels/types of Inquiry-Based Learning and their implementation.

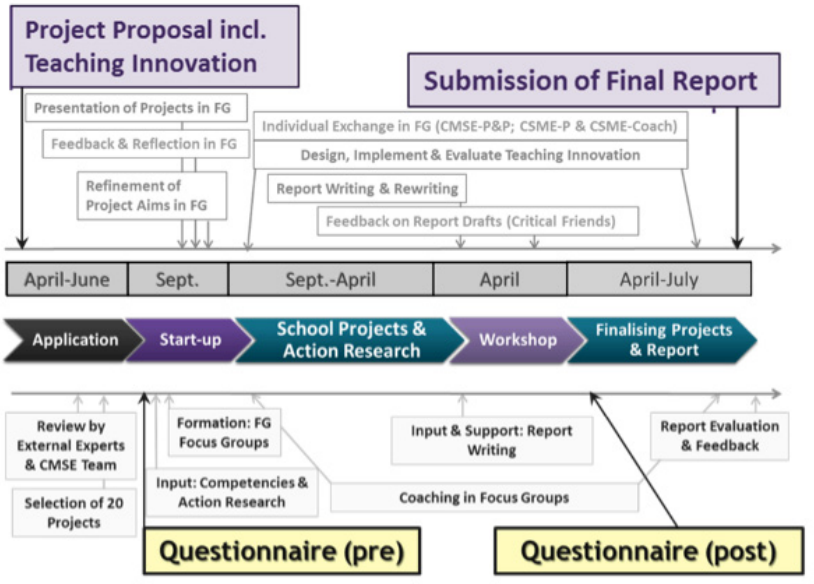

Figure 5. Research design and data collection (Haagen et al., 2017).

Qualitative and quantitative methods were used for data analysis: statistical frequency analysis with SPSS was used for the demographic data as well as for the multiple choice questions in the questionnaires. Qualitative content analysis (Mayring, 2014) was used for the open questions of the questionnaires as well as for the written documents (project proposals and final reports). We worked with the free online software QCAmap (https://www.qcamap.org/).

Categories were built deductively based on research on practical work and on models of IBL taken from research literature, as discussed in section II of the present paper (Theoretical Framework). These deductively generated categories did not portray the full data material, so it was necessary to extend the categories inductively.

Results

The general beliefs of CMSE participants about experimental work and IBL were collected with help of a pre-questionnaire. These findings were triangulated with the project proposals. Figure 6 shows the most important motives of the participants to use IBL when entering CMSE.

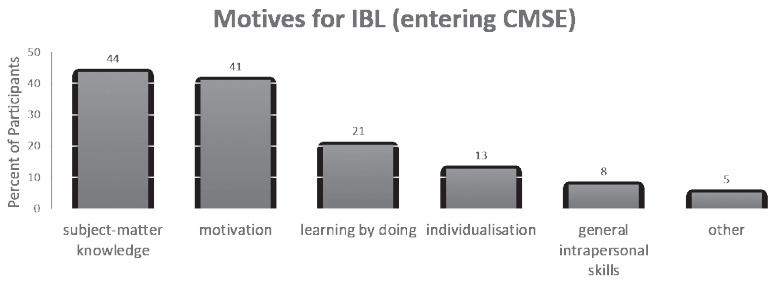

Figure 6. Motives identified by participants for using the IBL method.

It can be clearly seen that subject-matter knowledge is the most important function of IBL, followed by motivation, a learning by doing approach and individualisation in learning. The acquisition of experimental skills, the development of scientific reasoning skills, or gaining knowledge about how science works are not mentioned.

When participants were asked about the added value of IBL compared to other teaching methods, experimental skills (23.5%) were mentioned in the first place and inquiry competences (8.8%) were listed by at least a small minority. In addition, critical thinking (5.9%) and the development of problem-solving abilities (8.8%) play a role for some participants. Again, categories such as NOS aspects or how science works are neglected.

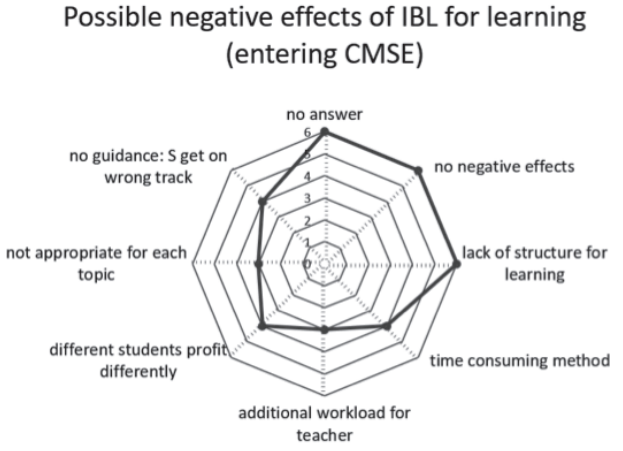

Figure 7. Possible negative effects of IBL for the learning process. Absolute numbers are given per category.

As far as negative effects for students' learning processes are concerned, the largest group of teachers (6) did not answer this question or denied negative effects (6). Another six teachers stated that students need well-structured learning environments for effective learning. Obviously, they related IBL only to unstructured open scenarios, or even to exploration. Other arguments addressed organisational issues, e.g., that IBL is very time consuming (4) or causes additional workload for teachers (3). Four participants mentioned that different students might profit differently in terms of knowledge gain, while another four thought that students might get on the wrong track without guidance. Another three teachers stated that not all topics are suitable for IBL. Learning about the Nature of Science was again not explicitly mentioned by any participants.

Teachers' knowledge about different phases or elements of Inquiry-Based Learning were investigated. Only two-thirds of the participants were able to name the different phases or elements of Inquiry-Based Learning. Figure 8 shows that the focus is clearly on observing (or collecting data) and documentation, as well as on setting up equipment, that is, on hands-on elements. Discussion was also frequently mentioned, although analysis or interpretation of data was, in most cases, not mentioned explicitly. From the descriptions, it could be deduced that, in most cases, experiences and observations should be discussed rather than data and interpretations deduced from data.

The phase of developing or posing questions often seems to be part of experimental work. The descriptions of these phases suggest that the questions given are typically not research questions in the narrow sense, but rather focus either on organisational issues or observables ("Does the piece sink or float?").

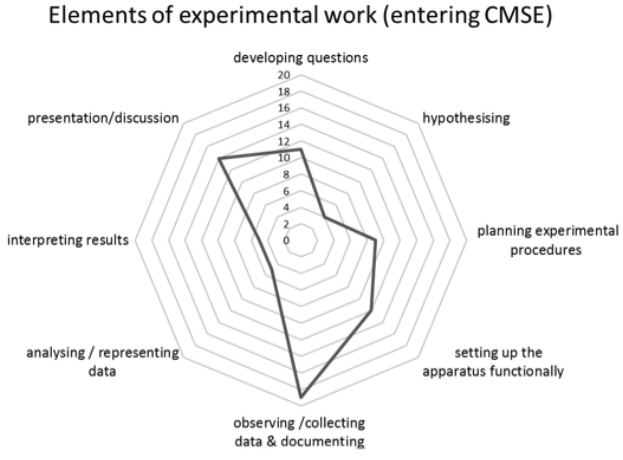

Figure 8. Focus on different phases or elements of Inquiry-Based Learning.

Another clue as to how diverse teachers interpret IBL can be seen from the categorisation of their projects concerning the use of IBL. When, during the entrance phase, participants were asked whether they used IBL in their projects, 84.6% categorised their project as inquiry-based. The same question was part of the post-questionnaire, at which point only 65.5% categorised their project as inquiry based. This effect is also in line with the analysis of project proposals and final-reports. Participants had obviously had a very vague idea of IBL: when entering the programme, they subsumed almost any experiment planned for the project as Inquiry-Based Learning. At the end of the course, however, the participants seemed to be much more aware of the concept and phases of IBL, and they consequently used the term in more reflected way.

Analysis of the data collected at the end of CMSE shows that the view on Inquiry-Based Learning had become more differentiated. Figures 9, 10 and 11 show the results of an item complex using a four-point Likert scale, where 1 means that the feature described is not prototypical of IBL, while 4 denotes that it is very prototypical for IBL. Figure 9 shows that teachers still emphasise the hands-on character of IBL. On the one hand, they categorise the inquiry process itself as open to multiple solutions but, at the same time, they restrict inquiry to right and wrong in terms of experimental procedure. Together with the emphasis on targeted research questions and hypothesising, this implies that, at this stage, the participants differentiate more clearly between inquiry and exploration than at the entrance phase.

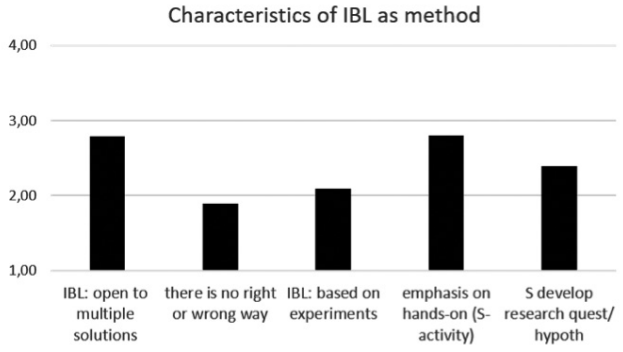

Figure 9. Characteristics of IBL as a method (perspective of participants, 1 = not prototypical; 4 = very prototypical).

As far as learning processes connected with IBL are concerned, Figure 10 shows that the initial belief that IBL works through a "learning by doing" approach (cf. Fig. 6) is still strong. In addition, content knowledge is still not seen

as a prerequisite for successful learning through IBL. On the other hand, the idea that learning processes in IBL are not pre-structured is disappearing, while the role of the teacher – who is not longer only in the background – is emphasised. Furthermore, the idea that IBL is highly typical of knowledge acquisition is no longer very strong.

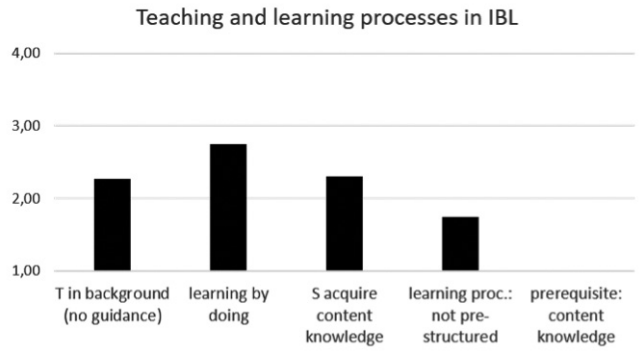

Figure 10. Prototypical aspects of learning processes in IBL (perspective of participants, 1 = not prototypical; 4 = very prototypical).

Finally, the aspect of how science works was analysed (see Fig. 11). The idea that students can act as scientists has been relativised. However, we obtain more ambiguous results regarding the characteristics of research. The participants do not view research as a typically targeted and systematic endeavour. On the other hand, they do not judge research as trial and error, either. In contrast to the entrance phase, the idea that IBL can support students to learn about the Nature of Science is present at the end of the CMSE programme, although there is still room for improvement.

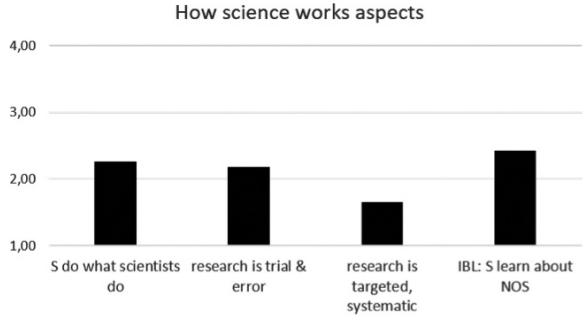

Figure 11. Aspects of IBL concerning NOS (perspective of participants, 1 = not prototypical; 4 = very prototypical).

Disscusion

The evaluation of our continuous professionalisation programme CMSE showed that the teachers in our sample are motivated by the national science standards to shift their teaching practice from input-oriented, teacher-centred teaching practices to more student-focused ones. A new impetus for experimental work can be observed, and Inquiry-Based Learning is a major trend among our sample. However, analysis of the data shows that ideas about the added value of experimental work and inquiry, and about their effective implementation, are very vague.

When entering the CPD programme, the motives for implementing IBL focus mostly on subject-matter acquisition and motivational issues. It is interesting that several **motives for practical work** and IBL known from literature (cf. section II of the present paper) were not mentioned at this stage: for example, the acquisition of experimental skills, the development of scientific reasoning skills, or gaining knowledge about how science works.

Before the CPD programme, the majority of the teachers viewed the **added value of experimental work** as being in student activity, learning by doing and the acquisition of subject-matter knowledge. Distinctions between targeted, science-oriented student activities such as IBL and the mere exploration or demonstration of phenomena are frequently not made. When we contrast these results with the definition of IBL used by the NRC (see section II.2 of the present paper), for example, we see that there is much more focus on experimental skills than on collecting evidence to "develop and evaluate explanations that address scientifically oriented questions" (NRC, 2000, 2006). Cognitive abilities such as "critical thinking" and "problem solving" are only mentioned as added value of IBL by a small minority of participants. The idea of "evidence-based reasoning" is not explicitly mentioned in either the questionnaires or the project reports.

This can be seen as an indication that many teachers may have a very unclear picture about the potential of practical work and IBL, a result that is in line with other research results, such as those discussed above by Singer et al. (2006).

When entering CMSE, the sample's view of the **restrictions of inquiry and potential learning difficulties** is very limited. It is astonishing that in both the pre-questionnaire and the project proposals there was no mention of IBL as a learning opportunity for aspects of NOS or for investigating how science works. In addition, it is very interesting that teachers, when asked about the possible negative effects of IBL on learning processes, use arguments on the

organisational level (e.g., "time consuming", "additional workload for teachers"). We can infer from this that some teachers tend to plan their lesson activities based on organisational aspects rather than focusing on learning processes. This impression was frequently confirmed in draft versions of the project reports discussed in our workshops. The participants' lesson planning was guided by organisational aspects or teaching methods rather than by student learning. Hardly any of their first drafts on interventions were inspired by a causal sequence of steps such as: intended learning goals / learning outcomes – students' prerequisites / needs / interests – interventions operationalising learning goals and considering students' prerequisites. Furthermore, there was a great deal of resistance among some of the participants to use any form of planning tool that follows the idea of didactical reconstruction, or to use planning processes starting from specific learning goals and student prerequisites. Such planning process were frequently seen as too time consuming and not helpful at all. Such attitudes and beliefs reflect a still very input-oriented view of education, which is not in line with competence orientation, but which seems to be deep rooted in many teachers.

As far as practical work is concerned, it was found that such an attitude is often accompanied by the use of cook-book style experiments, focusing mainly on content knowledge and taking into account only a few **experimental competences facets**, such as setting up apparatus, and collecting and documenting data. In the majority of cases, all other experimental competence facets, as described by Schecker et al. (2013) (see section III.3 of the present paper), were neglected at the beginning of the CPD.

To sum up, when entering CMSE, the sample's view of the restrictions of inquiry and the potential learning difficulties is very limited. The same is true of the differentiated perspective on the added value of practical work and IBL.

After the professional development course, the teachers' beliefs had only changed in certain aspects. It seems that some beliefs are very deep rooted, and that our participants tend to return to old, familiar patterns. On the other hand, the positive effects of the CPD course are that the participants **get a much broader view of experimental competences** and how they can be implemented in their teaching. They are much more likely to plan interventions that cover more experimental competence facets than observing, collecting data and discussing.

In addition, their initial low reflective level **concerning the way learning processes need to be structured** was partly improved. It was observed that it is very difficult to initiate the conceptual development of teachers in this perspective. A minority found it reasonably easy to adopt planning tools

that consider students' prerequisites and to set clear learning outcomes, which are operationalised in teaching interventions. However, the majority struggled with implementing such tools in their teaching practice, and some participants even rejected them openly from the beginning.

In general, IBL seems to be a very trendy teaching method. However, many practical activities are labelled as IBL despite failing to fulfil many of the criteria or characteristics of inquiry (cf. Hodson, 2014; Singer et al. 2006). This holds true for our sample, as well. When entering CMSE, the majority of the participants (nearly 85%) categorised their project as inquiry based in the application, although, as the results of our pre-questionnaire show, most of them were not familiar with characteristics of IBL. Conceptual changes on the level of our participants were, however, triggered concerning some characteristics of IBL, as the analysis of the project reports and the post-questionnaire show. In particular, the importance of guidance (cf. Kirschner et al., 2006) is recognised better and viewed as independent of students' expertise in IBL. As far as aspects of how science works are concerned, the initial naïve ideas could only be partly changed. On the one hand, it seems to be much clearer now that students cannot really act as real scientists and that research is not only trial and error (cf. Singer, 2006; Hodson, 2014); on the other hand, the idea that research is systematic and targeted, even on the level of students (NRC, 2000, 2006), has still not been fully internalised.

To sum up, we can conclude that our sample's beliefs concerning IBL were, in the majority of cases, not aligned with normative concepts. Our sample's level of professionalisation concerning these issues was low when they entered CMSE. Since the participants were selected by a review process, they represent a positively selected sample. Many of their colleagues may have an even less developed professional knowledge concerning experimental competences and IBL, despite the fact that these issues have dominated our education system for several years. Our programme helps the participants to achieve better use of IBL as a method, with more aspects and facets of IBL being implemented in their teaching practice. In addition, the participants' view of learning processes within IBL was partly modified. However, there are still several aspects, such as the idea of "learning by doing", in which pre-knowledge does not play any role in student learning. All in all, CMSE can be seen as a first step in individual professionalisation, although there is still room for improvement and further development.

Some general points for school practice can be deduced from these findings. First of all, teachers need to be aware that practical exercises involve more than just "doing" an experiment; experiments need to be well implemented in

physics or science lessons. This means that the implementation needs to be planned in a more student-centred way. Intended learning processes and learning goals, in combination with students' prerequisites, can determine whether experiments or IBL are an adequate means to support learning processes; not the other way round, whereby planning considerations begin from the experiment, ignoring systematic learning progressions and students' prerequisites as determining factors.

Secondly, instruments such as the spider-web (cf. Schecker et al., 2013) can help to ensure that all experimental competence facets are supported in physics or science instruction.

Thirdly, it is important that teachers are aware that IBL is not just "doing an experiment"; they should recognise that the acquisition of inquiry skills is a long-lasting and slow process. It takes students quite a long time to be able to develop adequate and meaningful research questions and an ability to hypothesise. Consequently, it is more frustrating than motivating for students when they are confronted with higher-level IBL tasks without thorough preparation.

Finally, it is important that teachers themselves develop a solid view of how science works and how IBL can help to make students familiar with an adequate view of the Nature of Science.

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Determination of the Size and Depth of Craters on the Moon

Vladimir Grubelnik[1], Marko Marhl[2] and Robert Repnik*[3]

Experimental work in the research of astronomical phenomena is often difficult or even impossible because of long-lasting processes or too distant objects and correspondingly too expensive equipment. In this paper, we present an example of observation of the Moon, which is our nearest astronomic object and therefore does not require professional astronomic equipment for observation. We focus on the observation of craters on the Moon, determining their lateral size and depth on the basis of photographs and simple calculations. The fieldwork with students of junior grade school education was performed within the framework of the optional subject Astronomy. An analysis of the results of the students' experimental work, as well as of curricula on various levels of education, led us to conclusion that this kind of experimental work is suitable for incorporation in secondary school physics education. With some mathematical simplifications, however, the treatment of the topic can also be appropriate in primary school. Such experimental work enables students to gain specific natural science and mathematical competences that are also required for the study of other natural phenomena.

Keywords: astronomic observations, craters, the Moon, natural science competences

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Določitev velikosti in globine kraterjev na Luni

Vladimir Grubelnik, Marko Marhl in Robert Repnik

Pri preučevanju astronomskih pojavov je eksperimentalno delo zaradi časovno predolgotrajnih procesov oziroma preveč oddaljenih objektov in s tem predrage astronomske opreme velikokrat oteženo oziroma nemogoče. V prispevku predstavljamo primer opazovanja Lune kot nam najbližjega astronomskega objekta, pri čemer ne potrebujemo profesionalne astronomske opreme. Osredinimo se na opazovanje kraterjev na Luni, pri čemer na podlagi posnetih fotografij in preprostih računskih operacij določimo velikost in globino kraterjev. Z namenom preučevanja, kako so posamezne faze eksperimentalnega dela primerne na področju izobraževanja, smo spremljali delo študentov razrednega pouka pri izbirnem predmetu astronomija. Na podlagi analize rezultatov eksperimentalnega dela študentov in analize učnih načrtov na različnih stopnjah izobraževanja smo ugotovili, da je omenjeno eksperimentalno delo primerno vključiti v pouk fizike na področju srednješolskega izobraževanja. Z določenimi matematičnimi poenostavitvami pa je obravnava problema primerna tudi v osnovni šoli. Poudariti velja še, da si učenci prek obravnavanega eksperimentalnega dela pridobivajo tudi nekatere naravoslovno-matematične kompetence, ki jih potrebujejo pri preučevanju drugih naravnih pojavov.

Ključne besede: astronomska opazovanja, Luna, kraterji, naravoslovne kompetence

Introduction

Experimental work in connection with the study of astronomic objects and phenomena often requires expensive astronomic equipment. Besides insufficient knowledge about complex working methods, this is the main reason for the lack of experimental work of this type in the educational area. In this paper, we present an example of experimental work using a telescope, where relatively simple astronomic equipment is sufficient (Astroshop.eu, 2017; Telescope: Meade ACF-SC 203/2000 8" LX200; Astro camera: The Imaging Source DFK), making it financially accessible for primary and secondary schools. The focus is on measurements of the diameter and depth of craters on the Moon's surface.

Craters on the Moon were first observed by Galileo Galilei, who made his first telescope in 1609 and used it to observe the Moon. He discovered that, contrary to general opinion at that time, the Moon was not a perfect sphere, but had both mountains and cup-like depressions, the latter of which he named craters. The word crater was adopted by Galileo after the Greek word for vessel: Κρατήρ – a Greek vessel used to mix wine and water.

Nowadays, there are numerous photographs, catalogues (Wang, Cheng, & Zhou, 2015) and generally available free applications, such as the Virtual Moon Atlas (Legrand & Chevally, 2012), that enable access to a great deal of data about the individual craters on the Moon. In the present paper, we focus on the determination of the diameter and depth of the Moon's craters; however, our aim is not only to obtain these data, but also to study how different phases of the corresponding experimental work suit treatment at different educational levels.

A crater's diameter and depth, or their ratio, are relevant parameters that indicate (within certain limitations) the conditions of the impact of a spatial projectile with the Moon's surface, conditions that influenced the formation of the crater (Scott, 2013). Several studies have been completed (Scott & Toalster, 2002; Scott, 2002, 2013; Scott, Shen, Mulley, & Pan, 2013) that illuminate the question of how to incorporate the problem of crater formation and the corresponding diameter-to-depth ratio in the curriculum for different educational levels. The focus of these studies is the connection between different subjects, in the sense of the scientific approach to solving problems related to the real world, whereby the students can compare their own findings with statistical data from professional scientific research (Scott & Toalster, 2002; Scott, 2002). Suggestions are offered regarding how we can, together with gifted students at different educational levels, determine the individual characteristics of craters with the help of adequately adapted theoretical derivations (Scott, 2013; Scott,

Shen, Mulley, & Pan, 2013), as well as with experimental work in the classroom (Scott, Shen, Mulley, & Pan, 2013). This exposes the use of scientific data that can serve as a starting point for theoretical derivations or as a verification of various conclusions. In the case of the study of craters on the Moon, data published by Pike (1976) in a catalogue of crater dimensions, compiled mostly from panoramic photographs taken on the final three Apollo flights, is mentioned several times.

The aforementioned studies focus on work in the classroom. In this area, however, there is a lack of research about experimental fieldwork, that is, studies addressing how students and teachers are trained for individual work phases within the framework of understanding the concepts and the preparation and realisation of experimental work, as well as analysis of the results. One study (Seanpuk & Ruangsuwan, 2017) points out, for instance, that most preservice teachers are hindered by a lack of knowledge and understanding, even regarding a phenomenon as simple as moon phases.

The present investigation uses known working methods for this task (Brglez, 2012; Kelemen, Šomen, Bohinec, Davidović, & Gomboc, 2010), with the objective of verifying their usefulness in practice. Our aim is to study how suitable individual working methods are for different educational levels, which working procedures require some emphasis to achieve better comprehension, and which procedures can be simplified within the framework of desired measurement accuracy to determine the diameter and depth of craters on the Moon.

In the paper, we first introduce the significance of the determination of a crater's diameter-to-depth ratio. Next, we describe the working methodology in more detail, introducing the course of the experimental work and exposing key working procedures that are the topic of investigation. Subsequently, we present the results, which can be grouped into three topical sets: 1) observation time, 2) work with a telescope, and 3) understanding mathematical working methods. We also provide an analysis of the results regarding the understanding of individual procedures, which offers a basis for simplification in order to enable treatment at different educational levels.

The significance of the determination of the diameter and depth of craters on the Moon

One of the main questions in the study of craters, which are formed by a collision between a projectile and the Moon's surface, is how to determine parameters that describe the crater's characteristics and enable an insight into the conditions of its formation. We are primarily interested in the initial conditions

of the impact, as well as the processes during the transformation of the crater into the final shape that can be observed now. Scott (2002) outlined an investigation into the factors that affect the topography of a simple lunar crater (Figure 1). The ability to predict the topographic dimensions of a simple crater have enabled planetary scientists to determine the stratigraphy of the Moon's crust (Dunkin & Heather, 1999).

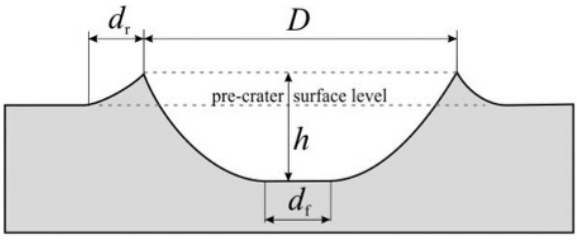


Figure 1. Cross section of a simple crater showing the principal features. (D – rim diameter, d_r – rim width, h – depth of crater, d_f – floor diameter)

The two most significant measurable parameters in the description of the crater in Figure 1 are its diameter D and depth h, or their ratio. However, there are some limitations of these data in the description of crater formation. When the depth and the diameter are measured, the two large structural parts of the crater are joined: the hollow dug below the initial surface level and the surrounding edge above the surface (Figure 1). In certain studies, such as the determination of the quantity of material dug in the formation of the crater, it is necessary to measure these two structural crater parts separately (Scott, 2013), but this is not so simple with the experimental methods that will be introduced below (Brglez, 2012; Kelemen, Šomen, Bohinec, Davidović, & Gomboc, 2010), as there is a problem with measurement accuracy. However, if we are only interested in the statistical relationship between the diameter and depth of the craters, our experimental methods are completely adequate. Some of the initial data about the size and depth of craters were, in fact, obtained in the same way. The diameter and depth of numerous craters on the Moon's surface have been calculated based on photographs from terrestrial telescopes and artificial satellites around the Moon, as well as with the knowledge of the angle of sunrays with respect to the Moon's surface (Baldwin, 1965; Pike, 1976; Short & Forman, 1972).

When measuring the diameter and depth of craters on the Moon, it is worth first informing students about the process of crater formation (Scott, 2013; Scott, Shen, Mulley, & Pan, 2013), as they often have misconceptions about the relationship between the size of the projectile and the crater.

The size of the projectile and the crater are similar only in the starting phase of crater formation, when the projectile collides with the Moon's surface: this is the so-called compression phase, as the material in the neighbourhood of the impact location is compressed. This phase depends directly on the momentum and kinetic energy of the projectile. The typical value of the projectile speed on impact with the Moon's surface is between 13 km/s and 18 km/s. After the compression phase, the projectile plays a minor role in the consequent digging of material and the transformation of the crater into the final shape. Part of the projectile and its material evaporates near the impact point due to the high speed and the kinetic energy on impact, and the expansion of the resulting hot gas causes an explosion that distributes the material. The shock wave causes a digging of material, so that a crater forms with a diameter a few times larger than the diameter of the projectile. In the next phase, the compressed material expands again, leading to a small rise of the crater centre, while part of the material from the gravitationally unstable edge and wall slips towards the centre of the crater. During this phase, the crater transforms from a semi-spherical to bowl-like shape, where the power law usually holds for the relationship between the crater's diameter and depth (Scott, 2002).

Methodology

Our aim was to establish the suitability of the individual phases of the experimental work to determine the diameter and depth of a crater for use in the area of education. We therefore investigated the work of students aged between 21 and 24 who were attending the optional subject of Astronomy in the third year of the first-cycle study programme The Primary School Teacher at the Faculty of Education, University of Maribor. The students serve as a representative sample from the hypothetical population. A total of $N = 47$ students participated in the research. They had no particular knowledge about handling optical equipment and searching for objects in the sky; it was a group of future teachers with middle-school knowledge of natural sciences and mathematical content. In the first year of study, they had attended a refresher course in physics and mathematics, without any specific astronomical topics. The students enrolled in the optional course in astronomy voluntarily based on their individual interest in the subject. The research sample included 47 students of the 2015/2016 and 2016/2017 academic years. They were not taught about the topic of the present research within the framework of the astronomy lectures. The group of students (combining two generations) was heterogeneous regarding their grades in science and mathematics subjects; however, it should be emphasised that, irrespective of their grades, all of the students enrolled in the course due their interest.

The results were obtained on the basis of solving tests, a questionnaire and an evaluation paper concerning our observation of the students' individual work phases, according to the three investigation topic sets mentioned above.

In the first part of the investigation, we were interested in whether the students could accurately estimate the appropriate time to observe Moon craters. Based on the students' work in the computer laboratory, we investigated their ability to search for data about the rising, setting and illumination of the Moon from a particular observation location. This phase is important for planning the time of observation, as the location of the Moon in the sky and its variable illumination influence observation conditions, particularly with regard to determining the depth of craters. In the second part of the investigation, we observed the students' work with a telescope, recording our findings about their skills. The objective of this part was to study how to motivate students for autonomous work when observing with a telescope. In the third part, which involved solving tests and a questionnaire, we investigated the students' understanding of the mathematical working methods that are required to determine the diameter and the depth of the Moon's craters from photographs.

Results

Below, we present the results regarding how the students understand and are able to perform the different phases of the task of determining the diameter and depth of craters on the Moon. The results concerning the estimation of the appropriate time for observations are given first, followed by the students' success in handling a telescope and their understanding of the mathematical relationships for the calculation of a crater's diameter and depth.

Determination of the observation time

The first phase of the task, conducted in the classroom, was dedicated to preparation for observation. In the limited time available, the task was for students to use the Internet to find the appropriate time for observing the Moon. We were interested firstly in the extent to which the students were able to find data about Moon visibility at a particular time, and secondly in their choice of the appropriate time to observe Moon craters. We should mention that all of the students included were skilled in searching for information on the Internet. Nevertheless, in the first phase of work, we analysed their skills in finding the specific information required for Moon observations. The time for this task was limited to 15 minutes, so that we could exclude students who had problems with target-oriented searching for information.

Visibility of the Moon at a particular time

As shown in Figure 2, 94% of the students successfully found the time periods of the phases of the Moon in the current month. It should be mentioned that they mainly used the web page *http://www.lunin.net/koledar/lunine-mene/*; although this is an astrological page, it nevertheless contains correct time periods of the phases of the Moon. As expected, the students had more trouble determining the appearance or illumination of the Moon's surface on a particular day (62%), as well as the determination of the rising and setting time of the Moon from a particular observation location (58%) (Figure 2). For the latter task, they mainly used the web page *http://vesolje.net/koledar/koledar.php*, where they could choose between some larger cities in Slovenia.

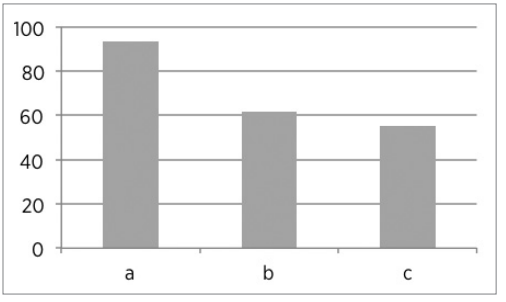


Figure 2. Visibility of the Moon.

The share of students who solved the specific task successfully: a) time periods of the phases of the Moon, b) illumination of the Moon's surface on a particular day, c) rising and setting time of the Moon from a particular observation location. The number of students included in the research was $N = 47$.

We found that the students needed some guidance regarding the web pages at which they could obtain data about the visibility of different objects in the sky. On the basis of the analysis of applications and web pages, we found that the most appropriate web page for the students was *http://www.heavens-above.com*, which offers the possibility of choosing any observation location on Earth, while also containing a large amount of data about various objects in the sky. There is also a mobile version of this application available, which facilitates fieldwork.

In our case, we can read the position of the Moon in the sky, its distance, the percentage of illumination, and the rising and setting times, as well as the time periods of its phases from a precisely defined position on Earth.

Appropriate time for observation

We were also interested in whether the students were able to choose

the appropriate time for the observation of Moon craters. The answer is not uniquely defined, but nevertheless there are some recommendations, as presented below.

Figure 3 shows the students' results regarding the suitability of the moon phases for observation of the size and depth of its craters.

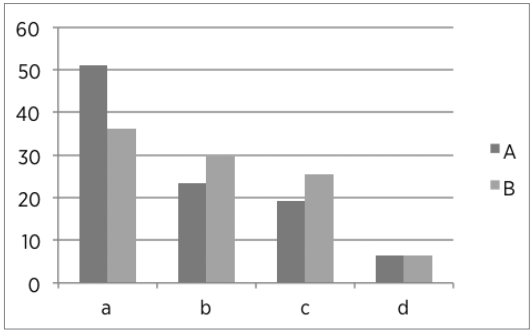


Figure 3. The students' opinions (expressed as a percentage) regarding the appropriate time for observation of the size (A) and depth (B) of craters on the Moon: a) full moon, b) first quarter, c) last quarter, d) independently of moon phases. The number of students included in the research was $N = 47$.

It is evident from the results that the students mainly chose the time of the full moon for both of the craters' dimensions. Their most common stated reason for this decision was that the entire visible part of the Moon (the side facing the Earth) is illuminated during this period. A slightly smaller share of the students chose the full moon for observation of the depth of craters (as opposed to observation of their diameter) because they were already aware that a good resolution of the craters' shadows is necessary in order to determine their depth. This reason was stated by students who chose answer *b* or *c*. It is, however, instructive that there is no significant difference in the frequencies of choosing answers *b* and *c*, which suggests that the students are unaware of the fact that the last quarter is observable only in the morning hours, which is not a good time for working with primary school students.

Based on these investigation results, we can conclude that it is necessary to instruct students regarding when each particular phase of the Moon is observable, and to stress the visibility of the craters' shadows in particular relative positions of the Sun, Earth and Moon. We inform students about the advantage of observing the Moon in the period of the first quarter again when the working methods for the determination of the craters' depth are explained.

Handling a telescope

The fieldwork with the students was undertaken within the framework of field exercises included in the subject Astronomy. This was the first observation work for the students within this subject. A reflective telescope MEADE ACF-SC 203/2000 8" LX200 (Astroshop.eu, 2017) with a focal length of 2 m was used. First, we observed the Moon through the eyepiece with various focal lengths, so that the students could get used to handling the telescope and acquire a feeling for magnification. Photos were then taken with the camera Imaging Source DFK 41AU02.AS Astro (Astroshop.eu, 2017).

We observed the students' work and wrote down our findings. We were interested in the following skills:

a) setting the sharpness of the image of the observed object;
b) adapting the telescope position in order to always keep the Moon in sight;
c) the correct choice of eyepiece according to the desired magnitude;
d) taking photos with the CCD camera.

For more than 70% of the students, this was their first experience of observing the sky through a telescope. Even those with previous experience had never handled a telescope by themselves. We therefore had to introduce the individual working methods and procedures to the students accordingly.

Despite these difficulties, the students quickly learned to handle the telescope. Setting the sharpness of the image (a) presented a minor obstacle for them, and some training was needed to acquire the skill of adapting the telescope position (b). However, the most problematic aspect was choosing the right eyepiece (c), with the students initially choosing among available eyepieces quite randomly. It was clear that they needed some additional explanation about the choice of the eyepiece, as well.

If we want to catch the whole Moon in the telescope lens, we have to choose a visual angle of 0.5°. When using the telescope LX200 with a focal length of 2000 mm, this visual angle is achieved with an eyepiece with a focal length of 20 mm and a visual angle of 52° (TS-Optics Super-Plözl, Series 4000, 52°). Here, the magnification of the telescope is 100 and the corresponding visual angle is 52°/100 = 0.52°.

Understanding the working methods

The focus was on commonly known methods related to determining the diameter and depth of craters on the Moon (Brglez, 2012; Kelemen, Šomen,

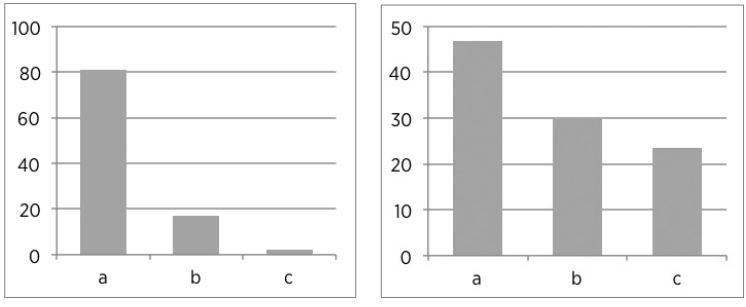
Bohinec, Davidović, & Gomboc, 2010), our objective being to establish the extent to which the students understood these methods. In order to determine the scale ratios of the objects on the photos, we needed digital photos of the Moon and a computer programme. We used the commonly known programme Microsoft Paint, which is among the Accessories of the Windows operating system.

Diameter of craters

If we want to calculate a crater's diameter, we use a simple calculation of the ratios of the known and unknown lengths. The procedure, which is described in detail on the web page of Martin Brglez (2012), was introduced to the students. We investigated the extent to which the students understood the procedure, as well as their awareness of the limitations and measurement errors connected with this task.

Figure 4A shows that the students had no problems with calculating the ratios in question (eq. 1), although it is somewhat surprising that 19% of them did not understand the method completely, despite the fact that ratios of this kind are treated thoroughly as early as in primary school.

As expected, the results regarding understanding the limitations of the aforementioned method were worse (Figure 4B). The method (eq. 1) gives the exact value only for craters that are in the centre of the circle in Figure 5, when the surface of the Moon is perpendicular to the observation direction. For craters outside this area, it is necessary to consider the projections of the inclination of the Moon's surface relative to the observation direction. It is obvious from figure 4B that more than half of the students were unaware of this problem.



A B

Figure 4. Percentage of students who understood the method for calculation of the diameter of craters on the Moon: A) Understanding of Ratios: a) complete, b) partial, c) not at all; B) Understanding the Limitations of the Method: a) it works for craters in the centre of the outlined circle; b) it works for craters at the terminator, c) it works for all craters. The number of students included in the research was $N = 47$.

As an example, we take a crater named Ptolemaeus (Figure 5), which has a diameter of 154 km (Legrand & Chevally, 2012). Taking the Moon diameter as $2r$ = 3,474 km, the students determined the following crater diameter (on average):

$$x = 2r \frac{x'}{2r'} = 152{,}2 \text{ km}, \quad (1)$$

where $\frac{x'}{2r'}$ is the ratio of the number of pixels on the screen.

We conclude that the relative measurement error in the students' work was about 2%.

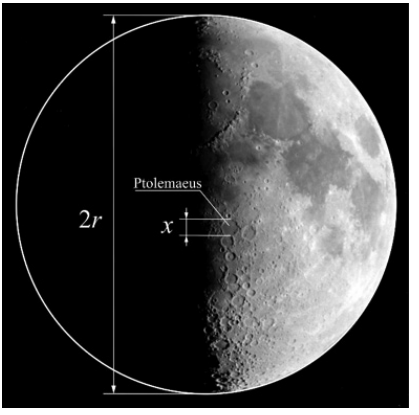


Figure 5. Determination of the diameter of a chosen Moon crater.

Depth of craters

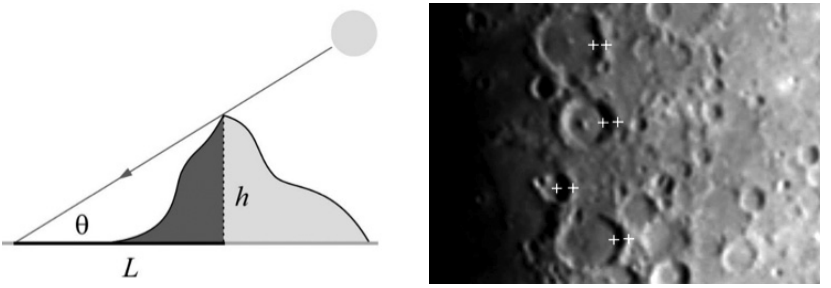
Regarding this task, a fairly accurate method was presented to the students, whereby the depth of craters or the heights of mountains on the Moon can be measured within an error of 10%. This method is described in more detail in the Slovenian astronomic review *Kmica* (Kelemen, Šomen, Bohinec, Davidović, & Gomboc, 2010). The method for mountain height h is based on the length of mountain shadow L (Figure 6A). The following relationship holds:

$$h = L \tan\theta. \quad (2)$$

Here, it is necessary to measure the shadow length (L) as accurately as possible, and to determine the angle (θ) between the sunrays and the Moon's surface.

The length of the shadow is determined in a similar way to the determination of the crater diameter, but we need to magnify the photo appropriately

and precisely determine the top (bottom) of the mountain (crater) and the edge of the shadow (Figure 6B). In this way, we determine the virtual shadow length, not the true length. In order to determine the true length of the shadow, we need to include the corresponding corrections due to the spherical shape of the Moon (Kelemen, Šomen, Bohinec, Davidović, & Gomboc, 2010). We will not explain these corrections here, as they were very difficult for the students to understand (Figure 7A). Furthermore, the corrections can be neglected, at least if we analyse craters near the point on the line through the observer on the Earth and the centre of the Moon. The error at craters lying within the apparent circle with a diameter one half of the apparent diameter of the Moon around the aforementioned point is roughly less than 15%. At larger distances from this point, the error increases rapidly.



A B

Figure 6. Determination of the height/depth of a mountain/crater: A) Ratio between the shadow length and the height; B) Determination of the shadow length on the photograph.

Finally, we also have to know the angle between the sunrays and the Moon's surface. There is a detailed explanation of this angle in the reference material (Kelemen, Šomen, Bohinec, Davidović, & Gomboc, 2010). Knowledge about spherical geometry is required in order to understand the mathematics of this problem; however, the majority of the students lacked such knowledge (Figure 7B).

With regard to this problem, one option is that we simply assume the correctness of the final equation:

$$\theta = \arcsin\left(sin\varphi \cdot sin\varphi_s + cos\varphi \cdot cos\varphi_s \cos(\lambda_s - \lambda)\right) \qquad (3)$$

Here, the pair of parameters (λ, φ) determines the position of the crater on the Moon, while the pair (λ_s, φ_s) gives the position of the so-called "subsolar

point", which is the point on the Moon where the Sun is at its zenith. We can find the crater position with the programme Virtual Moon Atlas (Legrand & Chevally, 2012), while the subsolar point can be found on the web page *http://www.lunar-occultations.com/rlo/ephemeris.htm* (Burnett, 2000), where we simply enter the time of observation. For instance, on the day of our experiments, 3 April 2017 at 21:00, the corresponding parameters in angular degrees were $\varphi_s = 1^0 S$ and $\lambda_s = 93{,}2^0 W$.

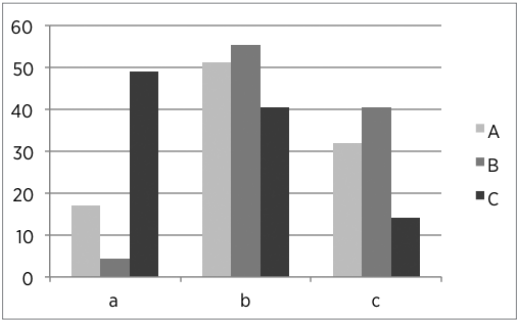


Figure 7. Percentage of the students with an understanding of the method for determining the depth of craters on the Moon: A) Understanding corrections of the length, B) Understanding spherical geometry for calculation of the position of the Sun above the horizon, C) Understanding the method with plane geometry; a) complete understanding, b) partial understanding, **c)** no understanding at all. The number of students included in the research was $N = 47$.

Since understanding the method in the reference material (Kelemen, Šomen, Bohinec, Davidović, & Gomboc, 2010) is too demanding for students, we suggest a simplified method, whereby the position of the Sun above the horizon is calculated within plane trigonometry (Figure 8), which is treated in secondary school. A better understanding of the simplified method is evident from the comparison of Figures 7B and 7C. In this way, the method turns out to be appropriate for teaching in secondary schools, as well.

In this case, the height of the sun is given as the difference of the angles (Figure 8A):

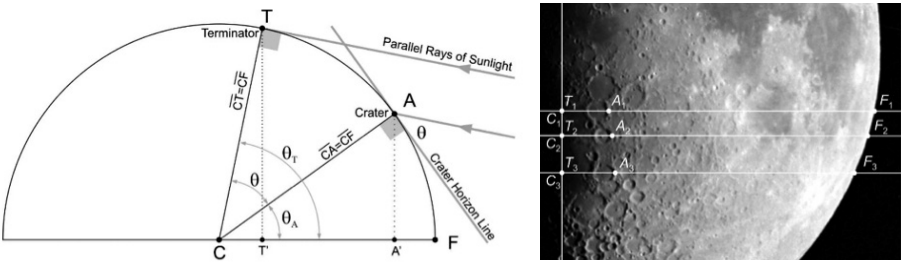
$$\theta = \theta_T - \theta_A \tag{4}$$

The angles θ_T and θ_A are calculated from the ratios of distances:

$$\cos \theta_T = \frac{\overline{CT'}}{\overline{CF}} \tag{5 a}$$

$$\cos\theta_A = \frac{\overline{CA'}}{\overline{CF}} \qquad (5\text{ b})$$

Using this simplification, the students measured the depth of craters within an error of 10%.



A B

Figure 8. Simplified method for determining the depth of craters on the Moon: A) Geometry with angles and distances in eqs. (4) and (5); B) Reading the ratio $\overline{CA'}/\overline{CF}$ in Eq. (5b).

If we are working with younger students, such as primary school students, trigonometry is either beyond their scope or, at best, known only on a basic level. The procedure in Figure 8 using equations 4, 5a and 5b can be performed through construction with a ruler and protractor instead of through calculation. This is of great importance for teaching younger students. This hands-on approach would also aid in understanding the concept of projection and angles much better than (only) inserting numbers into equations, which most students see as an abstract process, separated from easily imaginable geometric reality. With this approach, school students acquire the same physics in the easiest possible way, without difficult mathematical obstacles.

It should be emphasised that this method for determining the angle θ is correct for the longest value of $\overline{CF}$ in Figure 8B, where the plane, determined by the direction of sunrays and $\overline{CA}$ (Figure 8A), is perpendicular to the tangential plane of the Moon's surface at point A. For a shorter $\overline{CF}$ this method does not take into account the angle between the tangential plane of the Moon's surface at point A and the plane through point A, perpendicular to $\overline{CA}$ (Figure 8A). This error is more significant for craters near the terminator. We estimate that the value of this error does not exceed 15%, where $\overline{CF}$ is one half of the maximal $\overline{CA}$.

We did not systematically ask the students about their opinion of the topic and method of teaching (and possible suggestions for future work). However, we observed a high level of student motivation during all phases of

learning. In addition, the present teachers confirmed the positive impact of this course on the working atmosphere in the classes.

Conclusions

In education, the quality of the conditions for experimental work within the framework of astronomy topics is improving due to the enhanced interest of students and to projects that enable the financing of astronomic equipment (Vičar, 2009). In our case, the topic is the observation of craters on the Moon. We have shown that observation with a telescope can be upgraded with methods that enable the measurement of the diameter and depth of craters. Based on an analysis of the results of students' experimental work by individual phases, we found that experimental work involving the observation of craters on the Moon can be incorporated into physics or astronomy lessons at different levels of education by: i) introducing suggestions concerning searching for information, ii) using some crucial focuses in explanations, and iii) possibly applying appropriate simplifications to some otherwise demanding methods.

We found that students need some guidance regarding web pages on which they can find data about the visibility of various objects in the sky. On the basis of an analysis of applications and web pages, we found that the most appropriate web page for students was *http://www.heavens-above.com*, which offers the possibility of choosing any observation location on Earth and contains a large amount of data about various objects in the sky. In our case, we could use the website to find out the position of the Moon in the sky, its distance, the percentage of illumination, and the rising and setting times, as well as the time periods of its phases from a precisely defined position on Earth.

With regard to handling the telescope, the students did not have any major difficulties. The only explanation required concerned the choice of eyepiece for the desired visual angle of the Moon. The students can easily take photographs with adequate equipment. We should note that, when it is not possible to take photos, the students can use photos available on the Internet. However, they should take care that such images are comparable with images seen through a telescope lens. An adequate similarity of the image seen through telescope and the image from Internet must be achieved for the same moon phase and with clear visibility of the shadows of the craters. The resolution of the image from the Internet must be at least of the same quality as the image seen through the telescope, or better. In the case of better resolution, the students can investigate the influence of the resolution on the accuracy of the measurements. However, making photos of the Moon and other astronomic objects is

in general very motivating for students. This is an opportunity to incorporate this kind of experimental work into the students' other research work, such as measuring the apparent size of the Moon (Ellery & Hughes, 2012) and determining the size of the Sun (Guglielmino, Gratton, & Oss, 2010).

When calculating a crater's diameter, we use a simple calculation of the ratios of known and unknown lengths, which uses mathematics already acquired in primary school. However, it is necessary to warn the students that this method only works for craters where the Moon's surface is perpendicular to the observation direction. This requirement can be explained in more detail at a higher level of education. Similar findings hold for the estimation of the depth of craters (or the heights of mountains), where it is necessary to measure the lengths of the object's shadow as accurately as possible, and to determine the angle between the sunrays and the Moon's surface. We found that the method involving spherical geometry is too demanding even for most high school students. Thus, we suggest a simplified method with planar geometry, which students understand much better. In addition, this method gives measurement results with comparable accuracy to the more demanding method with spherical geometry when certain limitations are taken into account.

We should emphasise that the results of the present research cannot be generalised due to the specific properties of our sample. In a didactical sense, additional research needs to be done by testing students in primary and high schools. It is also important to test the teachers in schools where the sample is the most similar to our sample. The combined results may yield an optimal recommendation on how to provide experimental work for this topic in schools.

The method used for determining the depth of craters on the Moon can be upgraded with experimental work in class, whereby we can use the same method to determine the depth of craters formed by the impact of objects with soft ground (Scott, Shen, Mulley, & Pan, 2013). In a darkened classroom, we can apply different angles of light illumination to these craters. Furthermore, we can study the influence of the size and kinetic energy of the projectile, as well as the influence of the density and structure of the ground on the crater's size. Of course, it is necessary to inform the students about the main differences between the formation of craters in a school experiment and in the natural environment. The size of the crater in class is comparable with the size of the projectile, while the size of a naturally formed crater is several times larger than the projectile, as mentioned in section two of the present paper.

Based on our findings, we can conclude that, with some adaptations, experimental work such as that described in the present paper is appropriate for different educational levels, and that it enables students to gain specific natural

science and mathematical competences that are also required for the study of other natural phenomena. It is worth stressing the generic competences directly linked with the experimental work; for instance, the ability to collect and analyse information, and the ability to reach conclusions.

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Hands-On Experiments in the Interactive Physics Laboratory: Students' Intrinsic Motivation and Understanding

Marie Snětinová*[1], Petr Kácovský[2] and Jana Machalická[2]

Experiments in different forms can certainly be suitable tools for increasing student interest in physics. However, educators continuously discuss which forms of experimenting (if any) are the most beneficial for these purposes. At the Faculty of Mathematics and Physics, Charles University, Prague, two different forms of physics experiments are offered to upper secondary students: hands-on experimental work in the Interactive Physics Laboratory, and physics demonstration shows where the students watch experiments conducted by a lecturer. Our research focuses primarily on student feedback about their immediate attitudes towards these two projects. Data collection was undertaken using questionnaire research based on the Intrinsic Motivation Inventory. This research was subsequently supplemented with a qualitative study examining the influence of students' experimental work in the Interactive Physics Laboratory on their understanding of selected physics concepts. The results of the main research show that the two projects do not exhibit significant differences in terms of student interest and perceived usefulness; nevertheless, students felt the need for significantly more effort and experienced pressure during their work in the Interactive Physics Laboratory. One interesting finding, which goes against our original hypothesis, is that grades in physics are quite a strong predictor of students' assessment of the projects: better grades indicate more positive assessment of both projects as well as less pressure felt during hands-on activities in the laboratory.

Keywords: laboratory activities, upper secondary school students, intrinsic motivation, optics concepts, physics demonstrations

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Preprosti poskusi v interaktivnem fizikalnem laboratoriju: dijakova notranja motivacija in razumevanje

Marie Snětinová, Petr Kácovský in Jana Machalická

Poskusi v različnih oblikah so gotovo lahko primerno orodje za povečevanje zanimanja dijakov za fiziko, vendar učitelji kontinuirano razpravljajo, katere oblike poskusov (če katere) najbolj prispevajo k temu. Na Fakulteti za matematiko in fiziko Karlove univerze v Pragi ponujajo dijakom dve različni obliki fizikalnih poskusov: preproste poskuse v okviru interaktivnega fizikalnega laboratorija in demonstracijske fizikalne poskuse, v okviru katerih dijaki opazujejo poskuse, ki jih izvaja učitelj. Naša raziskava se primarno osredinja na povratne informacije dijakov o njihovih izkušnjah o teh oblikah. Zbiranje podatkov je potekalo z uporabo vprašalnika, ki je temeljil na vprašalniku The Intrinsic Motivation Inventory. Raziskava je bila posledično dopolnjena s kvalitativno študijo, ki je preučevala vpliv eksperimentalnega dela v interaktivnem fizikalnem laboratoriju na dijakovo razumevanje izbranih fizikalnih konceptov. Rezultati glavnega dela raziskave kažejo, da obe obliki ne kažeta pomembnih razlik v smislu zanimanja in dojemanja uporabnosti, vendar so dijaki občutili potrebo po znatno več truda in izkusili pritisk med njihovim delom v interaktivnem fizikalnem laboratoriju. Ena izmed zanimivih ugotovitev, ki je v nasprotju z našo prvotno hipotezo, je, da so ocene pri fiziki precej močen napovedovalec dijakovega vrednotenja omenjenih oblik: boljše ocene kažejo na pozitivnejše vrednotenje obeh oblik pa tudi manj pritiska, ki so ga občutili med preprostimi poskusi v laboratoriju.

Ključne besede: laboratorijske aktivnosti, dijaki, notranja motivacija, koncepti optike, fizikalni demonstracijski poskusi

Introduction

Physics (together with chemistry and mathematics) is among the school science subjects that are evaluated as the least favourite by upper secondary school students in the Czech Republic (Höfer, Půlpán, & Svoboda, 2005). However, this problem is not only the domain of the Czech Republic, but is widespread throughout the world. It is commonly stated that many upper secondary school students view physics as a difficult and boring subject (Veloo, Nor, & Khalid, 2015; Wong & Bakar, 2009). In order to show students the "beauty" of physics, science centres are being established across Europe and many physics faculties offer various out-of-school activities to students (physics demonstrations, shows, hands-on experimentation, interest groups, etc.).

The decline of student interest in and popularity of science, or more precisely physics, over the period of secondary education is a major concern to many science educators and researchers (Holstermann, Grube, & Bögeholz, 2010; Jack & Lin, 2017; Potvin & Hasin, 2014). Researchers are therefore focusing on finding ways to make physics more attractive to students (e.g., Owen, 2008).

According to Palmer (2009), many students lack motivation, but motivation is "an essential pre-requisite and co-requisite for learning". In his research, Palmer focused on situational interest – temporary interest that arises spontaneously due to aspects of a specific situation – and its sources, as interest is an effective motivator that can positively influence learning and test results (Laukenmann et al., 2003; Schraw, Flowerday, & Lehman, 2001).

Experiments in different forms naturally permeate all levels of physics education from the beginning of science teaching, and they undoubtedly play an important role when trying to understand the world around us in depth. Therefore, they certainly represent a suitable tool for increasing student interest in (and understanding of) physics. However, educators continuously discuss which forms of experimenting (if any) are the most beneficial for these purposes. Essentially, two main ways of performing experiments arise from previous comparisons: physics demonstrations conducted by lecturers (i.e., activities that are passive for students), and students' own experimental work (active involvement). These approaches are present in varying degrees in all levels of inquiry.

Focusing on experiments and other instructional strategies and their immediate impact on students, it is clear that active involvement (e.g., hands-on activities, doing experiments) together with novelty and social involvement (e.g., group work) play a key role in supporting students' situational interest

(e.g., Dohn, Madsen, & Malte, 2009; Palmer, 2009; Zahorik, 1996). Moreover, doing experiments and group work are not only liked by students, they are also considered useful (Owen, 2008). In comparison, passive activities are perceived more critically in terms of whether an activity is liked by students and how they view its usefulness.

As situational interest is an aspect of intrinsic motivation (Hidi & Harackiewicz, 2000), the aim of the present study was to explore students' perception of a learning activity that is used in our Interactive Physics Laboratory (IPL). The activity complies with the key elements for supporting students' situational interest: it is a hands-on activity with social involvement and it has a novel character for many students who attend the laboratory. It was also decided to compare student feedback about their immediate attitudes to the hands-on activity with their attitudes towards watching physics demonstrations (DEMOS) for upper secondary students. Questionnaire research based on the Intrinsic Motivation Inventory (n.d.) was used for data collection.

Although the main aim of the research was to explore the immediate impact of the two aforementioned projects on students, it was decided to execute an accompanying qualitative study examining the influence of students' experimenting in the IPL on their understanding of selected physics concepts.

As both research projects – the students' perception of learning activities and the influence of students' hands-on experimenting – are related to learning activities organised for upper secondary students by our department (the IPL and DEMOS), these activities are briefly described in the following section.

The Interactive Physics Laboratory

The Interactive Physics Laboratory was established by the Faculty of Mathematics and Physics of Charles University to provide upper secondary school students with a space for conducting physics experiments in the form of structured inquiry (Banchi & Bell, 2008). In groups of up to three or four, visiting students spend a total of 120 minutes in the laboratory, working on experimental units that together create an experimental set related to a particular physics topic. The IPL currently offers eight experimental sets (see Table 1), each of which consists of four to six units. The experiments contained in the units are mostly of a dual nature: they are either experiments that would be difficult to carry out in the classroom due to the amount of time required or equipment demands, or those that have the potential to strengthen students' conceptual understanding.

Table 1
Topics offered by the IPL (November 2017)

Electrostatics	Oscillations and rigid body mechanics
Motions under gravity	Rotating frames of reference
Magnetic field of solenoids	Thermodynamics I – quantitative approach
Optics	Thermodynamics II – qualitative approach

The main goal of the laboratory is to allow visitors to grasp physics with their own hands, both in the literal and the metaphorical sense. Students are given maximal autonomy: they perform all of the activities independently, including preparing measurements, and recording and evaluating data. Furthermore, at the end of each IPL visit, each workgroup describes one of the experimental units in a presentation lasting a few minutes, including major findings and results; the description should also be intelligible for workgroups that have not completed the unit being described (due to time constraints, in most cases students do not complete all the units of the experimental set.)

During the entire time of their visit, students can consult with lecturers regarding the steps of the experiment. The lecturers are normally students or younger employees of the Department of Physics Education. In conjunction with the students' own teachers, the role of the lecturers in the IPL is only to provide support.

Every unit has its own worksheet, which is given to the students to record their results. After the session, the students can take this sheet with them, thus giving their teacher an opportunity to build on the experimenting in the IPL in his/her subsequent regular lessons.

Demonstrations for secondary school students

At our faculty, the project of physics demonstrations (DEMOS) has a tradition of more than a decade. During both semesters, one forenoon a week is dedicated to an experimental show for upper secondary students, who visit the lecture hall with their teachers in groups of up to 90 persons. Each performance takes 75 minutes and is repeated three times in a row, meaning that more than 250 students can watch the show in one day.

At present, seven different physics topics are offered for teachers to choose from (see Table 2). The shows are overseen and executed by employees of the Physics Education Department.

Table 2
Topics offered for DEMOS (November 2017)

Acoustics	Electricity and magnetism
Electromagnetic radiation	Ionizing radiation
Mechanics	Optics
Thermodynamics	

Research focus

The IPL was put into regular operation in 2012, and since that time the number of visitors has grown continuously to the present level of more than 800 students going through the laboratory every year. The increasing interest of upper secondary school teachers and their students was the motivation to initiate a study on how visiting the laboratory influences students. This intention naturally offers two main research branches: one focused on the students' attitudes/motivation towards the executed activity itself, and the other aimed at potential changes in their conceptual understanding.

Although the literature search (see *Introduction*) revealed that researchers are still searching for suitable instructional strategies to support students' situational interest, it was decided to deal primarily with this topic, so that the data obtained could provide relevant feedback concerning the overall functioning of the IPL. The main part of the present paper is therefore focused on student motivation towards practical work in the IPL and, from this point of view, comparison with lecture demonstrations. The following text is based on this research and on our second, minor qualitative study, which focused on students' explanations of optics concepts. This is described at the end of the paper, in the subchapter *Does experimenting in the IPL influence the understanding of concepts in physics?*

Research questions

At the beginning of the study, the following research questions Q1–Q3 were stated, complemented with hypotheses H1–H3:

Q1: *Is there any statistically significant difference in the way practical work in the IPL is perceived by girls and boys?*

H1: According to our personal experience, we hypothesised that girls were more critical than boys.

Q2: *Is there any difference in the way experimenting in the IPL is perceived in comparison with perceptions of DEMOS?*

H2: We expected that experimenting in the IPL would be found to be more demanding by students, but more useful for them.

Q3: Is there any correlation between students' intrinsic motivation towards activities in the IPL and their grade in physics?

H3: We did not expect such a correlation.

In addition to these questions, we were naturally interested in which aspects of experimental work in the IPL were the most positively/negatively perceived in terms of students' attitudes/motivation.

Methodology

General research background

From a methodological point of view, a quantitative approach was used when trying to answer the research questions. The research plan was an ex-post-facto study, with the data being collected using a standardised questionnaire.

Sample selection

The study focused on upper secondary school students taking physics courses as part of their general education programme. The sample was made up of students who had visited the IPL or DEMOS on the discretion of their teachers. From this point of view, a selective effect must be taken into account, so the sample cannot be considered representative, e.g., it could be suggested that teachers bringing their students to the IPL or DEMOS are more engaged and active in looking for attractive teaching approaches, so their students could be accustomed to a "high level" of teaching.

Moreover, another strong effect is determined by the fact that both projects are situated in the Czech capital Prague, and visiting students live mostly in the capital or its immediate surroundings.

Data was collected from a total of 1,122 upper secondary school students aged from 15 to 19. In the IPL, the sample is made up of 303 visitors (145 girls and 158 boys), whereas in DEMOS it includes 819 visitors (412 girls and 407 boys).

Research tool

The Intrinsic Motivation Inventory (n.d.) was used as a research tool. This multidimensional measurement device is based on the Self-Determination Theory, and its primary goal is to assess participants' subjective experience related to activities performed in laboratory experiments. In both the original and a modified version, the Intrinsic Motivation Inventory (IMI) has been

repeatedly used in many previous studies (Deci, Eghrari, Patrick, & Leone, 1994; Leng, Wan Ali, Baki, & Mahmud, 2010; Monteiro, Mata, & Peixoto, 2015; Plant & Ryan, 1985; Ryan, 1982; Ryan, Mims, & Koestner, 1983). The use of this tool far exceeds the limits of education: for instance, psychologists use the IMI with business employees, children, athletes, people with mental illnesses, etc.

In the original IMI, students express their intrinsic motivation towards the studied activity on seven subscales: *interest/enjoyment*, *perceived competence*, *effort/importance*, *felt pressure/tension*, *perceived choice*, *value/usefulness* and *relatedness*. To be precise, only the first scale measures the intrinsic motivation itself, while the others either serve as positive/negative predictors for intrinsic motivation or express other motivational aspects of the participants' attitude towards the assessed activity.

McAuley, Duncan and Tammen (1987) demonstrated the high validity of the IMI scales (with the exception of the last one, which was added later) and later studies suggest that the exclusion of any scale does not influence the results in the others, nor does the order of items in a particular scale.

The full-length IMI consists of 45 items and was translated into Czech in 2012. For the purposes of our research, we used 23 items (19 for DEMOS); we decided to entirely exclude the scales *perceived choice* and *relatedness*, as they are irrelevant to our conditions. In addition, the scale *perceived competence* was excluded from the DEMOS research. The students should assess every item on a seven-point Likert scale ranging from *this claim is not at all true for me* (scored by 1) to *this claim is very true for me* (scored by 7). In our study, we emphasise the problem of the usefulness of practical work in the laboratory, which is why the scale *value/usefulness* is represented by more items than any other.

Procedure

The study was designed so as to administer the IMI in the form of a paper-and-pencil questionnaire immediately after the assessed activity: experimental work in the IPL, or watching experiments in DEMOS. Before they left the laboratory or the lecture hall, students were given time to fill in the IMI, supplemented with a few personal questions (gender, age, year, grade in physics). Most of the students completed this task within five minutes, but there was no upper time limit for completing the questionnaire.

While the students were completing the IMI, the lecturers always left the room where the students were sitting, in order to exclude any influence of the lecturers' physical presence on the participants' decisions.

Data collection in the IPL took place from April to October 2017. During this time, a total of 303 students from 25 workgroups and 12 different upper

secondary schools were involved in the study. Collecting data during the DEMOS project took place from May to October 2017, during which 12 different thematic shows took place and 819 students from 16 schools were engaged in the research.

Data analysis

For each IMI item, elementary statistics were calculated, including average score, standard deviation and variance; to calculate the final score for reverse items, the average value obtained was subtracted from 8. Subsequently, the score for each IMI scale was calculated by averaging scores across all of the items on that scale. Gender-separated data were analysed in the same way and compared using a two-sample *t*-test. Similar *t*-test-based comparison was made for data obtained in the IPL and in DEMOS.

Results

General and gender-separated data

As mentioned above, data from more than 1,100 respondents was collected and subsequently processed by statistical methods.

The basic data for particular IMI scales is summarised in Table 3. The correlations of the scales are shown in Table 4 (for IPL data) and Table 5 (for DEMOS data).

As explained above, the respondents assessed every item on a seven-point Likert scale ranging from *this claim is not at all true for me* (scored by 1) to *this claim is very true for me* (scored by 7), i.e., the higher scores in the following tables correspond to stronger student feeling on the measured scale.

Table 3
Basic data obtained by the IMI questionnaire

scale	average score	SD	var	average score		*p*-value
				Girls	Boys	
data from the IPL						
interest / enjoyment	**5.54**	*1.52*	*2.30*	**5.47**	**5.52**	.704
perceived competence	**5.17**	*1.56*	*2.44*	**4.98**	**5.32**	.016
effort / importance	**4.67**	*1.65*	*2.73*	**4.73**	**4.60**	.319
felt pressure / tension	**2.45**	*1.56*	*2.42*	**2.43**	**2.42**	.942
value / usefulness	**5.58**	*1.48*	*2.20*	**5.60**	**5.54**	.672

scale	average score	SD	var	average score		*p*-value
				Girls	Boys	
data from DEMOS						
interest / enjoyment	**5.67**	*1.17*	*1.37*	**5.61**	**5.72**	.154
effort / importance	**4.10**	*1.28*	*1.64*	**3.98**	**4.21**	.063
felt pressure / tension	**2.34**	*1.04*	*1.07*	**2.24**	**2.43**	.063
value / usefulness	**5.51**	*1.00*	*1.00*	**5.57**	**5.46**	.117

Note. From left to right, the columns show: average scale score, standard deviation, variance, and the comparison between boys' and girls' average scores, complemented by the *p*-value arising from the *t*-test for the two independent samples. The higher the score, the stronger the students' feeling of measured quality (interest, effort, pressure, etc.).

Table 4

The Pearson correlation table for the IMI scales resulting from the IPL data

perceived competence	.53			
effort / importance	.67	.42		
felt pressure / tension	-.24	-.42	-.07	
value / usefulness	.72	.49	.58	-.21
	interest/ enjoyment	perceived competence	effort/ importance	felt pressure/ tension

Table 5

The Pearson correlation table for the IMI scales resulting from the DEMOS data

effort / importance	.59		
felt pressure / tension	-.03	.13	
value / usefulness	.70	.47	-.09
	interest/enjoyment	effort/importance	felt pressure/tension

In terms of test reliability, both of the IMI questionnaires administered (IPL and DEMOS) exhibit a Cronbach alpha higher than 0.85 (Cronbach, 1951).

Correlation with grades (IPL only)

In the Czech school system, upper secondary school students are graded in particular subjects with marks from 1 to 5, where 1 is the best assessment and 5 the worst. While only a few students stated in the questionnaire that their last term grade in physics was 5, we excluded these responses from the following comparison and analysed the dependence of IMI scores on grades from 1 to 4.

Table 6 shows the Pearson correlation between the grade and the average scores in each scale for IPL visitors.

Table 6
Correlation between grades and IMI scores

half-year grade in physics	interest/ enjoyment	perceived competence	effort/ importance	felt pressure/ tension	value/ usefulness
1	5.65	5.59	4.79	2.31	5.65
2	5.48	5.05	4.59	2.38	5.63
3	5.44	5.12	4.67	2.51	5.60
4	5.12	4.72	4.33	2.58	5.16
Pearson correl.	-.95	-.91	-.86	.99	-.83

Item analysis

For a deeper analysis, Table 7 contains the average score for every item, both in the IPL and DEMOS samples. The (R) stated at the end of some items identifies that these items were assigned in reverse, in order to verify that students had not chosen contradictory answers, which be could sign of a random strategy when completing the questionnaire.

Table 7 contains a generally used version of the IMI items. However, in the questionnaires we used, the phrases "this activity" or "this task" were replaced by "experimenting in the IPL" (in the case of the IPL) or "watching experiments" (in case of DEMOS), both complemented by minor, language-conditioned changes in word order.

Discussion

Gender differences

Generally, the differences between boys and girls are only minor in most of the scales investigated, and do not confirm hypothesis H3 that girls are more critical of practical work in the IPL; the same conclusion can be reached regarding watching DEMOS. At level $p < 0.02$, we registered only one dimension, *perceived competence*, with a statistically significant difference in gender comparison. This means that, while experimenting in the IPL, boys feel more competent and satisfied, and are probably more self-confident when assessing their own ability to perform well.

What is remarkable, however, is the perception of *effort/importance* when comparing the IPL and DEMOS. While girls assess experimenting in the

laboratory as requiring more effort in comparison with boys, for DEMOS the situation is exactly opposite: girls feel less effort is required (with low significance $p < 0.1$).

Comparison of the IPL and DEMOS

According to the data obtained in the research, students find both experimenting in the IPL and watching experiments during DEMOS quite interesting and useful: on the scales *interest/enjoyment* and *value/usefulness*, both activities achieved an average score over 5.5 (remembering that the mean value of the Likert scale used is 4.0). This is in contradiction with the researchers' claims that watching experiments is less liked by students than hands-on experimenting (see *Introduction*; Owen, 2008).

The differences between the IPL and DEMOS scores in these two scales are statistically insignificant, as are gender-conditioned differences; this is true not only for the entire scales, but for almost all of their items, as well. Expectedly and logically, the exception is item 14, which is focused on developing manual skills.

In the case of the two remaining scales (of a total of four that can be compared), statistically significant differences were identified. On the scale *effort/importance,* three out of four of its items show at $p < 0.005$ that greater effort is required by experimenting in the IPL than by watching DEMOS. The absolute average scores move around the scale mean of 4.0 for DEMOS, while for the IPL they move around slightly higher values. This could indicate that students devote appropriate effort to both activities, but not extreme effort.

Table 7

IMI items with the achieved scores for the IPL and for DEMOS

no.	scales + items	score IPL	score DEMOS	*p*-value
Interest / enjoyment		**5.49**	**5.67**	**-**
5	This activity did not hold my attention at all. (R)	*5.78*	*6.02*	*.009*
9	I thought this was a boring activity. (R)	*5.74*	*5.88*	*.197*
13	While I was doing this activity, I was thinking about how much I enjoyed it.	*4.85*	*4.98*	*.251*
15	I enjoyed doing this activity very much.	*5.60*	*5.78*	*.052*
Perceived competence		**5.16**	**-**	**-**
4	I was pretty skilled at this activity.	*5.28*	-	-
19	This was an activity that I could not do very well. (R)	*4.79*	-	-
21	I am satisfied with my performance at this task.	*5.36*	-	-
23	After working at this activity for a while, I felt pretty competent.	*5.18*	-	-
Effort / importance		**4.66**	**4.10**	**-**
3	I did not put much energy into this activity. (R)	*4.39*	*4.32*	*.505*
12	I did not try very hard to do well at this activity. (R)	*5.46*	*4.41*	*< 0.005*
17	I tried very hard in this activity.	*4.68*	*3.90*	*< 0.005*
20	I put a lot of effort into this activity.	*4.11*	*3.76*	*< 0.005*
Felt pressure / tension		**2.42**	**2.34**	**-**
2	I did not feel nervous at all while doing this activity. (R)	*2.05*	*1.86*	*0.022*
6	I felt very tense while doing this activity.	*2.73*	*3.16*	*< .005*
11	I felt pressured while doing this activity.	*2.03*	*1.74*	*< .005*
16	I was very relaxed in doing this activity. (R)	*2.89*	*2.61*	*< .005*
Value / usefulness		**5.57**	**5.51**	**-**
1	I think doing this activity could help me to understand physics concepts.	*5.95*	*6.07*	*.175*
7	I think this is an important activity.	*5.55*	*5.58*	*.939*
8	I think it is useful to do this activity because it can increase the attractiveness of physics.	*6.09*	*6.11*	*.878*
10	I think doing this activity could help me to handle physics at school.	*5.15*	*5.22*	*.603*
14	I think doing this activity is useful for gaining manual skills.	*4.91*	*4.38*	*< .005*
18	I would be willing to do this again because it has some value for me.	*5.55*	*5.30*	*.018*
22	I think experimenting in the IPL will be useless for me at school. (R)	*5.78*	*5.90*	*.240*

Note. The *p*-value was obtained by using a *t*-test for two independent samples. The null hypothesis expects that the particular item is assessed equally by both of the studied populations, and it is rejected at the level $p < .005$.

The only scale that shows average scores lower than the mean value of 4.0 is the scale *felt pressure/tension*. For items 2, 11 and 16, the gains for DEMOS are lower than for the IPL, and in the last two items this difference is statistically significant; according to this, DEMOS is less stressful for students than laboratory work, which is not surprising if we consider that watching DEMOS (unlike the IPL) does not require students to demonstrate any physics knowledge. Interesting results are offered by item 6, where students should assess the statement "*I felt very tense while doing this activity*"; unlike the other items of the scale, it shows a significantly higher score for DEMOS. We hypothesise that this could arise from two possible meanings of this item: while some students could interpret *tension* as a negative manifestation of stress, for others it could it a pleasant, exciting feeling of expecting something unusual. In the latter case, such an interpretation could bring DEMOS a higher score, as the show intentionally works with expectations and excitement.

The correlation matrix shown in Tables 4 and 5 suggests that there are generally no strong correlations between any of the scales; the only remarkable Pearson coefficient (higher than 0.70) was identified between *interest/enjoyment* and *value/usefulness*. The effectively zero correlation between *effort/importance* and *felt pressure/tension* scales practically excludes the hypothesis that students who assessed both of the activities as non-stressful did so because they do not devote appropriate effort.

Grades

As Table 6 shows, better grades generally increase students' assessment in all of the scales, with an exception of the *pressure/tension* scale, which exhibits a strong correlation with grades. In other words, the worse the student's grade, the more pressure s/he felt during activities in the IPL.

Does experimenting in the IPL influence the understanding of concepts in physics?

As mentioned above, one of the experimental sets offered in the Interactive Physics Laboratory is focused on geometrical and wave optics. The experiments are divided into four units with the following topics: (1) *Reflection & refraction of light*; (2) *Total reflection*; (3) *Interference & diffraction* and (4) *Polarisation of light*. Although the students' visit to the laboratory is a one-time event, we decided to prepare a study in order to explore whether the IPL has an influence on secondary school students' understanding of selected concepts in optics.

The research described below is an accompanying qualitative study investigating the influence of students' hands-on experimenting in the IPL on their understanding of selected physics concepts. A qualitative research approach was chosen for the purposes of this study. A questionnaire with open-ended questions, in which students should describe the selected physics concepts, was prepared for data collection. The questionnaires were evaluated using content analysis of students' written answers, as assessed by three independent researchers.

Sample selection

The survey was carried out in spring 2017.

Two secondary school teachers who visited the Interactive Physics Laboratory with their students were asked to be involved in the survey. The participants were 46 students aged 16–17, most of whom (24 boys and 15 girls) attended the optical experimental set in the IPL in three different groups.

Description of the intervention

All of the students who visited the IPL within the framework of the research can be divided into two groups: one group completed units (1) and (2) with experiments from geometrical optics (22 participants: 13 boys and 9 girls), while the other group (17 participants: 11 boys and 6 girls) undertook wave optics experiments, i.e., units (3) and (4). Thanks to this division, during their visit to the IPL, every student encountered two of the physics concepts investigated in the prepared questionnaire. Thus, the answers of students who had encountered a particular physics concept in the IPL were compared with the answers of students who had not encountered that particular concept in the IPL, or with the answers of students who had not visited the laboratory at all.

Three weeks after their visit to the IPL, the students were asked to complete the prepared questionnaires. They were asked to describe, as precisely as possible, the following concepts:

(a) physical phenomena that occur in a water droplet when a rainbow is formed;
(b) the principle of working of an optical fibre and travel of a light ray through the optical fibre;
(c) what is observed on the screen during a double-slit experiment and why this happens;
(d) what happens with linearly polarised light as it passes through optically active solutions with different concentrations.

The students did not have any teaching aids at their disposal while completing the questionnaires.

All of the described concepts are commonly discussed during the optical experimental set in the IPL. Simultaneously with the execution of the survey, the students studied optics during their normal physics lessons at secondary school, as well (according to the curricula and the teachers' statements); they should therefore be familiar with all of the phenomena addressed in the questionnaire.

Results

In the first question, which focused on the formation of a rainbow, there were no differences observed between the students who had visited the corresponding unit in the IPL and the others. Nevertheless, it is very interesting that the students often mentioned dispersion and refraction of light to describe the origin of a rainbow, whereas reflection of light in the water droplet only rarely appeared in the students' answers. Furthermore, none of the students mentioned the double reflection of sunlight inside raindrops, which causes secondary rainbows.

The students who had taken unit (2), which focuses on total reflection, were more successful in answering the question about optical fibres. Their responses were more detailed, they used collocations that can be found in the worksheets for the IPL, they often mentioned "ideal case", and they described total reflection more precisely than the other students. The students also drew the picture of optical fibre that appeared in the worksheets, and their pictures were correctly drawn.

Examples of two answers of students who had taken the unit focused on total reflection:

- *"In order to be a total reflection, the light must not pass out through the walls of the fibre."*
- *"The light must not be seen when I look at the fibre, i.e., 100% of the light transmission comes out."*

The double split experiment was surprisingly well explained by both groups of students. Terms such as Young's experiment and interference figure, as well as appropriate pictures, appeared in both of the researched groups. Nevertheless, a better understanding of the concept can be found among students who had taken the corresponding experiments in the IPL. Their responses were more detailed, and there were only three students who had entirely incorrect explanations or no explanation of the physical phenomena (in the group that

had not attended the unit focused on interference and diffraction, there were thirteen students without a correct explanation).

The last phenomenon, optical activity, was the most difficult for the students to describe. It is evident that both the students who had attended unit (4), which is focused on linear polarisation, and the students who had not taken it had considerable difficulties with the explanation of this physics concept. In our opinion, the main obstacle for the students was the difficulty of the topic. The students have problems even understanding the linear polarisation of light, which is hard for them to imagine.

An unexpected result emerged in the last question about optical activity, as well. In their answers, several students who had visited the IPL but had not attended the particular unit described an experiment involving bending a laser beam in a water tank with sugar (this experiment was part of unit (2) and describes the forming of mirages). Furthermore, the students' responses were often supplemented with an illustrative picture. In all probability, the reason for the confusion of these two experiments is caused by the formulation of the question, where the collocation "differently concentrated optical active solutions" is used. The students could connect this formulation with the fact that they need an environment with a gradient of refractive index to observe mirages, and this environment can be created by a sugar solution whose concentration is constantly changed from the bottom to the surface.

The study also identified the students' obstacles regarding terminology. The students often mistook the word "diffraction" for "dispersion", and vice versa. The phrase "refraction of light" is perceived by students in the sense of "any change of direction of the light ray", and therefore is often used as an alternative for "reflection".

Conclusions

In the main part of our paper, we describe a quantitative study dealing with students' intrinsic motivation and related attitudes towards practical work in the Interactive Physics Laboratory, on the one hand, and towards physics demonstrations, on the other. The research was conducted from spring to autumn 2017.

Using a translated and slightly modified IMI questionnaire, we obtained data from more than 1,000 respondents, with a similar number of girls and boys. Gender differences appeared to be only minor, with the exception of the *perceived competence* scale (administered only in the IPL), where boys state stronger feelings of competency and self-confidence when experimenting

independently. In general, hypothesis H1, which assumed that girls would be more critical, can be rejected not only for the IPL, but also for DEMOS.

In comparison with DEMOS, the assessment of the IPL does not exhibit significant differences with regard to *interest/enjoyment* and *value/usefulness*. On the other hand, while experimenting in the IPL, students feel the need to invest significantly more *effort* and experienced a higher level of *tension*. Therefore, hypothesis H2 can be rejected only partially: the students in the study do not see a difference between the usefulness of practical work and watching demonstrations, but they do find the former to be more demanding. The question remains as to whether (and how) the *real*, not only perceived, usefulness of experimenting during DEMOS and in the IPL differs. In connection with this question, we sought to determine what students remember from the experiments they watched during DEMOS and from the experiments they undertook in the IPL.

Contrary to hypothesis H3, grades in physics appeared to be quite good predictors of IMI scores, while averages in particular scales correlate relatively with students grades: better grades are an indicator for more positive IMI assessment.

The research presented opens opportunities for follow-up investigation in the field of student motivation towards different forms of experimenting. We now intend to conduct more extensive research investigating how students' attitudes towards different forms of experimenting correlate with their attitudes towards physics, and to determine the motivation of teachers to bring their students to the IPL and DEMOS.

From the results of the present qualitative, understanding-oriented study, we can formulate the hypothesis that students' experimenting in the IPL has an impact on achieving better understanding of demonstrated physics concepts. However, it is necessary to take into account the difficulty of the given phenomena and the emphasis placed on the students' understanding of the phenomena in their regular physics lessons.

It would be appropriate to build on this study with quantitative research that would clearly confirm or disprove our hypothesis in the future. At the same time, we would like to prepare a similar study for some of the other physics topics that the IPL offers.

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Let's Repair the Broken Galileo Thermometer

Marián Kireš[1]

We have developed and verified laboratory work as guided inquiry for upper secondary level students, focusing on conceptual understanding of the physical principle that forms the basis of temperature measurement, and on improvement of selected skills. Conceptual pre-test questions initiate the students' interest and help identify input misconceptions. Using the method of interactive lecture demonstration, the students are introduced to the measurement principles of the Galileo thermometer. The students are then set the problem of how to repair a broken thermometer when tap water is used instead of ethanol. Since the density of water is greater than that of ethanol, the buoys must be adjusted by the students to achieve correct temperature measurement. The next steps of the activity have a hands-on orientation. The students work in pairs, guided by worksheet instructions. At the end of the activity, they complete self-assessment rubrics focused on skill improvement and final conceptual understanding. The results of the conceptual pre-test questions and of the self-assessment rubrics from 461 participants are analysed and recommendations are made for teachers.

Keywords: conceptual understanding, Galileo thermometer, guided inquiry

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Popravimo pokvarjen Galilejev termometer

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Razvili in evalvirali smo laboratorijsko vajo, vključujoč učenje z raziskovanjem, za dijake, osredinjeno na konceptualno razumevanje fizikalnega principa, ki je osnova za merjenje temperature, in na izboljšanje izbranih veščin. Vprašanja na predpreizkusu znanja spodbujajo dijakovo zanimanje in pomagajo identificirati začetne napačne predstave. Z uporabo metode interaktivne demonstracije na predavanju se dijaki seznanijo s principom merjenja z Galilejevim termometrom. Dijaki nato oblikujejo problem, kako popraviti pokvarjen termometer, ko je uporabljena voda iz pipe namesto etanola. Ker je gostota vode večja kot gostota etanola, morajo dijaki prilagoditi plovnost termometra, da dosežejo pravilne meritve temperature. Naslednji koraki aktivnosti vključujejo preproste poskuse. Dijaki delajo v parih, sledijo navodilom za delo z delovnih listov. Na koncu aktivnosti izpolnijo vprašalnik za samooceno s poudarkom na izboljšanju veščin in končnem konceptualnem razumevanju. Rezultati predpreizkusov znanja in vprašalnikov za samooceno 461 udeležencev so analizirani in podana so priporočila za učitelje.

Ključne besede: konceptualno razumevanje, Galilejev termometer, vodeno raziskovanje

Introduction

Contemporary science, engineering and technology bring a vast array of topics, the understanding of which is required in order to motivate and engage students for their sustainable development in the future. In formal education, there is a great deal of inertia and conservatism, which unfortunately results in a failure to address content innovations systematically and dynamically. Our aim is to suggest an approach to processing current topics that follows the school curriculum and opens up new horizons for the students. In order to ensure the development of these topics, we seek to demonstrate their benefits and strengthen the determination of teachers to include them in school education programmes.

Flotation, buoyancy force and the Archimedes' principle are among to the basic topics of physics courses. We can determine the existence of a buoyancy force when we observe diving and flotation, and this topic is reasonably easy to remember for the vast majority of students. In our practice, however, we have encountered mostly just learned facts, without conceptual understanding. In order to solve new situations, only a consistent understanding can ensure success.

Just the key concepts, which require conceptual understanding, are appropriate topics for inquiry educational activities. The interactive nature of the suggested customised activity creates understanding of the topic or concept. The activity is conducted with a worksheet, or with the instructions of the teacher, with partial steps including assessment and discussion. The student first formulates his/her findings using existing knowledge, and his/her results are then corrected in the discussion with the teacher. An important part of the follow-up of the educational activity is formative assessment. Students use self-grading instruments to express the degree of satisfaction with their own level achieved in the area of conceptual understanding, as well as the development of selected skills. We classify this educational approach as "guided inquiry".

Guided inquiry brings a substantial change to the teacher's educational approach, whereby the "new concept" is the result of the student's activity as a learner. As well as obtaining new skills, new findings will be formulated at the end of the activity. Guided inquiry allows for the development of a skill through experimental activity; its key component is a problem, a challenge for any student.

In order to implement guided inquiry in schools, it is necessary to prepare teachers on how to manage the entire educational process.

The complexity of such a process is illustrated by the findings of the IAP report (IAP, 2010), which identified six issues associated with efforts to

introduce inquiry activities into secondary schools where traditional teaching methods are used:

- The demands of the curriculum content and lesson schedules.
- The impact of tests and examinations; particularly the use of results for high stakes decisions affecting students and teachers. This creates pressure, which distorts content and teaching methods, deters the use of inquiry and obstructs the formative use of assessment by teachers.
- The relevance of science as perceived by students.
- Teachers' subject knowledge.
- The use of new technologies, which, although it has many benefits, can produce situations where students learn in isolation.
- The balance of continuity/discontinuity at transfer from primary to secondary level. An abrupt change in school culture, organisation of teaching and nature of science teaching at transfer from primary to secondary school can cause a decline in performance and in effective response to science.

From our perspective, it is necessary for the teacher to gain self-confidence and inner conviction about the educational feasibility of the activity. Preservice teachers are significantly more likely to use innovative approaches than older teachers with years of experience.

Teachers may fail to fully understand the concept of inquiry for many reasons. Many teachers have acquired little or no scientific research experience in their own education, which may contribute to their lack of scientific content knowledge (Zion et al., 2007). Furthermore, teachers' lack of knowledge about the nature of science can be a barrier to implementing IBSE-teaching (Roehrig & Luft, 2004). Most teachers have inadequate ideas about science, and there is a complex relationship between teachers' stated beliefs about science and how they actually present science in their classrooms (Abd-El-Khalic & Lederman, 2000). Studies show that many teachers teach scientific content in preference to the nature of science (Sadler, Amirshokoohi, Kazempour, & Allspaw, 2006).

For the student, active learning involves a significant change in communicating skills and the acquisition of new knowledge. In an effort to encourage a change in the approach to active learning, we utilise the informal environment of the centre for the popularisation of science SteelPARK Košice (www.steelpark.sk). The student, as well as the teacher or lecturer, pays more attention to his/her own educational activity, teamwork, results and findings, and to the formulation of conclusions. In conjunction with attractive content and modern methods, the educational activity contributes to more spontaneous student behaviour and greater motivation for work. In addition, our fun

science centre exhibition offers visitors active interaction with more than fifty exhibits demonstrating the story of steel, from the field of metallurgy, geology, physics, chemistry, safety, engineering and others. The exhibits are prepared in such a way that it is possible to carry out observations with them repeatedly without the help of an instructor. The visitor usually perceives the activities as a game, the aim of which is to observe a selected phenomenon.

Within the SteelPARK centre, we have organised the Inquiry Science Laboratory, which has been operating successfully for the last three years. So far, we have designed and implemented 16 educational activities at the level of guided inquiry. Groups of students participate in research activities under the supervision of a trained lecturer (a future teacher). The lecturers are students, including PhD students, and future teachers of science subjects. School classes, which are divided into two groups, attend a laboratory where they participate in parallel activities led by trained instructors. The monthly attendance is approximately 400 students, and a total of around 9,000 students from secondary and elementary schools have attended to date. The teacher follows the work of the lecturer, evaluates the progress of the activity, and receives all of the supporting materials for applying guided inquiry in his/her own teaching. Future teachers gain practical experience with innovative approaches to teaching and the associated assessment tools, while students are encouraged to engage in active discovery, bolstering their self-esteem. Verifiable educational activities and a database of research findings are shared with a wide community of teachers in order to encourage the STEM system. One of these activities is: Let's Repair the Broken Galileo Thermometer.

Methods

Action research principles were used to validate the prepared learning activities. The objectives are:

- to structure and develop a conceptual understanding of the key topics in physics education;
- to prepare the activities using the inquiry-based science education (IBSE) approach, in order to improve conceptual understanding and develop research skills;
- to prepare, support and motivate future teachers and practising teachers to teach with the use of IBSE.

The respondents are students of primary (age 12–15 years) and secondary schools (age 15–18 years), future teachers and practising teachers. The

instruments for the implementation of the research are: observation of the work of the lecturers and students, evaluation of questionnaires of teachers supervising course activities, interviews with lecturers, analysis of completed worksheets, analysis of students' answers to conceptual questions, and the development of self-assessment sheets. The resulting products are educational activities and recommendations on their implementation.

Research design

The method of design-based research was used for educational materials, development and guided inquiry method proofs. Design-based research can be described as a cycle: analysis of a practical problem, development of solutions, iterative testing of solutions, reflection and implementation (Reeves, 2006).

The central element of inquiry activities is a problem, an educational challenge for a student and his/her enthusiasm and motivation to solve it. One interesting problem with an experimental approach is the issue of the Galileo thermometer (Güémez, 2009).

Problem

Glass-walled buoy-like spheroids containing a coloured liquid are immersed in an enclosed cylinder full of liquid. Attached to each spheroid is a small metal tag indicating a temperature in a range of two degrees Celsius. At a given temperature, some of the spheres rest at the bottom of the cylinder, while others float at the top of the liquid column. In an ideal case, one buoy floats at a particular depth close to the middle of the cylinder. Such a device is called a Galileo thermometer. Galileo thermometers, with a predetermined number of coloured spheres usually floating in a high cylindrical container, are well known and widely used (Ucke, 2017). The Galileo thermometer was not, in fact, invented by Galileo himself, but Galileo did discover the principle that liquids change their density with temperature. The small glass spheres are partly filled with different coloured liquids. The composition of these liquids is not important for the functioning of the thermometer; they merely function as fixed weights and their colours are only for decoration. The liquid in which the bulbs are submerged is not water, but some organic compound (such as ethanol), the density of which varies with temperature more than water does. Temperature changes affect the density of the outer clear liquid, thus causing the bulbs to rise or sink.

P1: How does such a device work?

Each of the floating spheroids displaces a weight of fluid equal to its own weight, while the others either displace too much or too little liquid to float at a specific position within the cylinder. Such a statement derives from Archimedes' principle.

Figure 1. Galileo thermometer.

The column of isothermal liquid has a density ρ that depends on the depth in the fluid given by (Nickas, 1989):

$$\rho = \rho_o \left(1 + \frac{g\rho_o y}{B}\right)$$

Where: B is bulk modulus, ρ_o liquid density at the surface, y depth in the liquid, g gravitational acceleration.
Bulk modulus is defined as:

$$B = \rho_o \frac{dp}{d\rho}$$

Where: $dp = g\rho_o dy$
Once the buoy is floating, we set the density of fluid equal to that of a buoy to produce depth of floating, y:

$$y = \frac{B(\rho_b - \rho_o)}{g\rho_o^2}$$

The change in temperature changes the density of the liquid. The surface density can be written as a function of temperature T as:

$$\rho_o(T) = \rho_o(T_o)(1 - \beta(T - T_o))$$

Where the quantity β is the coefficient of fluid volume expansion, and T_o is the initial temperature.

The change in temperature influences the buoy depth by:

$$\Delta y = \frac{\beta B}{g\rho_0} \Delta T$$

The coefficient of the thermal volume expansion of glass is up to 20 times less than that of liquids at room temperature. The spheroid will respond reasonably negligibly to temperature changes compared to the responding liquid. Only the liquid in the cylinder is considered temperature sensitive for the action. The spheroid rises with a decrease in temperature and sinks with an increase. The correct temperature is indicated by the temperature on the suspended floater. If there is no suspended floater, the temperature is bounded between that of the upper and lower floaters. A change in temperature would require a "new" floating spheroid to replace an "old" one at the same depth.

The sensitivity of such a thermometer would be given as the ratio of change in depth and change in temperature ($\Delta y/\Delta T$). For water at room temperature ($\beta = 2 \cdot 10^{-4}\ ^{o}C^{-1}$, $B = 2 \cdot 10^{-9}$ Pa, $g = 10\ ms^{-2}$, $\rho_0 = 10^3\ kgm^{-3}$), it is around 40m/°C. However, for such a sensitive device one would have to construct buoys with differing masses of only ± 0,2mg/cm³ of volume for 1°C temperature change. Galileo thermometers are now built and sold all over the world for decoration purposes.

P2: Our favourite thermometer was broken during cleaning, but the buoys remained. You want to fix the thermometer using a beaker filled with water instead of ethanol. Suggest how you need to modify the buoys in order to make the thermometer work correctly again. Verify your proposal with an experiment.

How is the task solved?

In order to solve the assignment, we will use: two beakers, glass, water, buoys from the original thermometer, metal wire, digital scales with a precision of ±0,01 g, pliers, a ruler and a digital thermometer.

Worksheet instruction for students.

1. Verify how the buoys behave in water.
   - Measure the temperature of the water in the glass and note down the data.
   - Carefully and gradually dip all of the buoys into the beaker with water. Note down how the individual buoys behave. We know that $\rho_{etylalcohol} = 789\ kgm^{-3}$, $\rho_{water} = 1000\ kgm^{-3}$

- Decide whether it is possible to determine the temperature of the water from the layout of the buoy.

Write down your observations.

2. Teach the buoys to measure the temperature even when they are submerged in water.
   - Using a digital thermometer, measure the water temperature in the cylinder and record the data.
   - Select a buoy with a temperature lower than measured, and insert it carefully into the cylinder.
   - The buoy should fall to the bottom. However, water is denser than ethanol, so the buoy remains just below the surface. Select the buoy. Cut a piece of wire, measure its length and weigh it. Write down the measured values. Hang the wire on the label of the buoy and then put it back into the cylinder with water.
   - By gradually shortening the wire, find the appropriate weight at which the buoy sinks very slowly to the bottom. Determine the weight of the wire for each length, and gradually complete a table with the data.

   Work in a group. Write down your findings.

3. Verify that the buoy recognises a different temperature.
   - The buoy calibrated on a lower temperature than the temperature of the water in the cylinder slowly sinks to the bottom.
   - Insert the buoy into water that is colder than the water to which it has been calibrated.
   - Describe its behaviour and decide whether it responds correctly to the water temperature.

   Work in a group. Write down your findings.

4. Suggest a procedure for the "warmer" buoy.
   - Design a procedure for adjusting a buoy to define a temperature greater than the actual temperature of the water in the cylinder.
   - Describe how you would verify its functionality at a different temperature.

   Discuss in the group. Write down your procedure.

5. Formulate the conclusion of today's measurements.
   Discuss in the group. Write down your results and conclusions.

We propose this educational activity as guided inquiry. The teachers involved in the study were prepared for the implementation of the activity in both aspects: professional and research. For verification, we used the informal environment of the science centre, where we had prepared five workplaces for groups of two or three students. Mapping the level of conceptual understanding, we executed a series of questions in a concept test, which the students completed in the introductory part of the activity. The lecturers only commented briefly and evaluated the answers. The teacher supervised the course of the activity and evaluated the checklist. At the end of the activity, the students completed self-assessment sheets. The data from the worksheets, the concept tests, the self-assessment sheets and the teachers' evaluations were processed during the activity, then summarised for all of the participating groups of students. The result of the research is an educational activity backed by support materials, as well as the formulation of recommendations for its implementation.

Sample

The prepared activity was suggested to schools as part of school excursions to the science centre. After discussing the topic as part of their school study plan, teachers enrolled their school class of lower secondary (12–15 years old) or upper secondary (15–18 years old) students. A total of 461 students from surrounding schools, both rural and urban, participated in the study. The sample can be considered random, as the availability of students from both urban and rural schools was without significant restrictions. The students were in groups of five, three or two, working much as they do during normal school classes. The implementation of the activities took 60 minutes. In each activity, there is basic content and augmented content, so the lecturer can effectively use the time according to the readiness of the students. The science teacher observed the whole process and was able to assist our lecturer in communicating with the students.

Instruments

The input data was collected using a questionnaire consisting of four questions focused on students' preconceptions of floatation, the principle of buoyancy forces, and the topic of temperature measurement.

Q1: List the various types of thermometers.
Briefly write down the principle governing the operation of a thermometer.

Q2: Draw in all of the forces that act on the body submerged in the liquid in the picture. Mark the forces and write down what they are called.

Q3: Three bodies are placed in a container with water. One is on the bottom, another is floating in the middle of the container, and the third is floating on the surface. Compare the density of the bodies with the density of water.

Q4: Objects submerged in liquid are buoyant. How do you explain the fact that liquid (e.g., water) knows that it has to float the submerged body?

The answers to the following questions are written on the student worksheet:

W1: Temperature is usually measured in °C. Describe some temperatures that we can encounter in our everyday life. You may have encountered a temperature measured in K or °F. Explain how this differs from the value taken in °C. In your own words, explain what is meant by the term temperature. Discuss in the group. Write down your opinions.

W2: Without the use of a thermometer, try to determine: the temperature in the room, the temperature of cold and hot water in a beaker, the temperature of the skin on your hand. Why do we need a thermometer to determine the temperature? Discuss in the group. Write down your opinions.

W3: Look at a few types of thermometers that are available. Name them and try to determine how the different types of thermometers can measure temperature (based on what principle influences each of them). Generalise how a thermometer works. Discuss in the group. Write down your opinions.

W4: Observe the Galileo thermometer set up on the table, a thermometer immersed in cold water, and a thermometer submerged in hot water. Try to measure the temperature of each thermometer. How can the Galileo thermometer measure temperature? Based on what principle does it work? Discuss in the group. Write down your opinions.

W5: Check how a buoy behaves in water.

W6: Make buoys measure the temperature even when they are submerged in water.

W7: Verify that the buoy measures a different temperature.

W8: Suggest a procedure for the "warmer" buoy.

From the point of view of self-evaluation, analyse the students' answers to the questions:

SE1: In today's activity, Let's Repair the Broken Galileo Thermometer, I have learnt …

SE2: The most the interesting thing for me during the activity was …
SE3: One question to which I still don't know the answer is …

Table 1
Self-evaluation skills of the student after the activity

RATE THE RESULTS OF YOUR WORK			
After this activity, I know how to...	**With considerable assistance**	**With assistance**	**Individually**
Explain the principle of the functioning of the Galileo thermometer			
Measure the temperature with the help of the Galileo thermometer			
Adjust the buoys so that they can measure the temperature			
Formulate conclusions on the basis of personal observations			

Results

Based on the 461 respondents' answers to the conceptual questions, the self-evaluation and the evaluation of the acquired skills, it is possible to state the following.

Q1 When asked, the students list as examples of a thermometer: mercurial, digital, laboratory, medical and bimetallic. They mention the liquids inside the thermometer, the various metals or the electric current, but the principle of operation is not described. In most cases, the students absolutely do not understand the physical principle (volumetric thermal tensibility, change in the electrical resistance, variation in the length of tensibility). They merely state information about the types of thermometers they can remember, without understanding how they work.

Q2 When the students specify the forces, they make the following mistakes: specifying of forces is completely missing, only the force of gravity is drawn, all of the forces are outside the floating body, the forces affect only the surface of the body at the place of contact with the liquid, the point of affection of gravity and the buoyancy force is the same, the buoyant force effects the bottom part of the body.

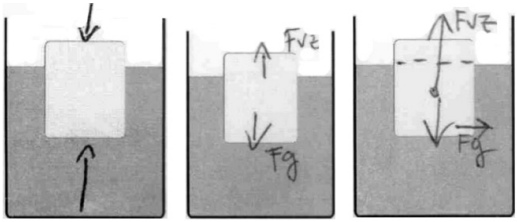

Figure 2. Typical student answers regarding forces acting on a floating body.

Q3 The students have a correct understanding of the comparison of densities between bodies and water.

Q4 None of the answers were correct. The existence of buoyancy forces matches reality; it is described by the fact that a body with lower density will float in a liquid with greater density. Students consider this to be a fact. The mechanism on the basis of which expulsion exists is unknown to them.

We noticed that there were no entries whatsoever on many of the worksheets. In discussions, we found out from the students that writing is done only if their teacher dictates it. The following problems were determined by an analysis of the worksheets: important formulas were missing in the part regarding findings, there was a low level of procedure logging, there was a low level of discussion in groups, the ability to formulate questions separately was weak, and there was a complete absence of arguments. It is clear that the students are not used to producing records from measurements separately. However, our findings could be partially distorted by the informal environment in which the measurements were made.

During the final self-evaluation, the students were asked to state what they had learnt during the day. We expected answers focused on acquired knowledge and skills related to the conducted activity.

SE1 We were surprised by the high percentage of absent answers, despite the free choice of the formulation. From the point of view of acquiring new knowledge, responses are distributed as follows (Figure 3).

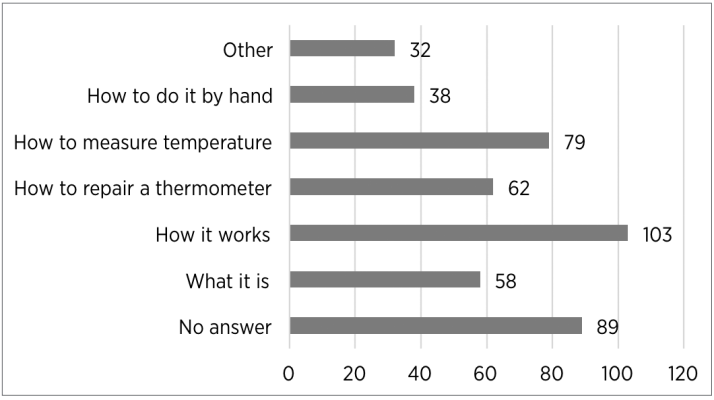

Figure 3. Students' answers related to acquiring knowledge.

At the end of the activity, the students were asked to state what was most interesting for them. The students' responses are compared with our stated educational goals.

SE2 The most interesting aspects for the students were that they were acquainted with a new temperature measuring device, that they could modify the buoys, and that they could work independently.
The answers correspond with our goals.

The questions that remained unanswered were intended to provide an impulse for the revision of the activity, so that it could be renewed or modified in order to eliminate significant deviations from our stated goals.

SE3 We expected the formulation of physical problems related to the measurement of temperature, buoyancy, measuring precision, etc. This revealed the poor ability of students to formulate questions. Interestingly, we received questions such as: What would the ideal weight of the wire for the buoy be? Why do the droplets of liquid have different colours? What is the measuring range of the thermometer?

The answers obtained from the 461 students using the self-evaluation sheet of acquired skills after the completed activity are shown in Table 2. The most common answers are highlighted. The number of correct answers decreases with the increase in the mental difficulty of the evaluated activities.

Table 2
Results of students' self-assessment after the activity

RATE THE RESULTS OF YOUR WORK				
After this activity, I know how to...	**No answer**	**With considerable assistance**	**With assistance**	**Individually**
Explain the principle of the functioning of the Galileo thermometer	16.3%	9.1%	56.4%	18.2%
Measure the temperature with the help of the Galileo thermometer	13.4%	1.7%	17.6%	67.2%
Adjust the buoys so that they could measure the temperature.	14.8%	30.4%	43.6%	11.3%
Formulate conclusions on the basis of personal observations	16.1%	32.1%	35.8%	16.1%

Discussion

By the end of 2017, we had developed and audited 16 different educational activities organised with the approach outlined above. To date, the activities have been attended by a total of approximately 9,000 students. We are purposefully reaching out to schools in order to repeat their participation in subsequent activities. In most respects, we have made progress in: communication with lecturers, active research, working with worksheets, and providing students with experience in guided inquiry. In addition, we can demonstrate that the safe environment of the Science Centre positively impacts the promotion of the inquiry approach among students, especially during repeated visits to the organised activities. Students feel more comfortable, acquire experience with the task, behave more spontaneously, and achieve better results.

In some instances, the teacher accompanying the students is not a physics teacher. In these cases, there is a drop in the level of influence, as such teachers cannot sufficiently appreciate the benefits of the methodology for active learning. Teachers of physics, on the other hand, are open to constructive criticism. In subsequent activities, they recognise the potential for using what they have seen in the school educational process. They also identify obstacles, such as the lack of technical equipment, the lack of physics lessons in the school curriculum, and the large classes, usually of approximately 30 students. Teachers appreciate the work of the trained and experienced lecturers, which bolsters their self-confidence and their willingness to apply guided inquiry in their own work.

In analysing the work of the lecturers, future teachers of physics, we look for positive feedback on guided inquiry. In particular, they appreciate the interactive discussions and the independent work of student groups, the possibility to select the parts to be used in the activity, the support of students in active research, and the possibility of joint conclusions. In conclusion, we would very much appreciate the opportunity to gain practical experience, particularly thanks to the informal environment of the Science Centre.

Based on our experiences from this activity and with target groups, we introduced an assessment questionnaire in which teachers responded to the following questions (T1 – T7). The questions are teacher-focused, concerning the core elements of our activities, the meaning of the steps and partial tasks, as well as the acquired results. In addition, an interview with experienced teachers was undertaken to obtain a detailed overview of the activity's success.

T1: For the students, the activity was (mark only one option):
a) very interesting
b) interesting
c) somewhat interesting
d) mostly unimpressive
e) unimpressive

T2: In terms of time, the proposed activities in the inquiry science laboratory were:
a) unmanageable in the specified time
b) manageable with an active group of students
c) manageable with a standard class
d) manageable in a shorter interval

T3: Taking into account the level of the students, the prepared worksheet was:
a) very difficult
b) rather difficult
c) adequately challenging/manageable
d) rather easy
e) easy

T4: What relationship does the knowledge of students acquired in school have with the information contained in the activity?
a) The activity complements the material that the students have already learnt.
b) The activity deepens the material that students have already learnt.
c) The activity extends the students' knowledge.

d) Other .....

T5: Do you want to conduct the activity next time? (mark only one option)
a) Yes, I want to conduct the activity in the inquiry science laboratory as a teacher, and I expect only assistance from the lecturer.
b) Yes, I want to actively conduct activities in the lab, but the lecturer should remain as the main presenter.
c) I want the lecturer to lead the activity.
d) Other...

T6: Are you planning to repeat the activity that the students have undertaken in the lab during class in school?
a) Definitely
b) Most likely
c) I haven't decided yet
d) Probably not
e) Definitely not

T7: Are you planning to assess the students for their work in the inquiry science laboratory; for example, based on the worksheet?
a) Definitely
b) Most likely
c) I haven't decided yet
d) Probably not
e) Definitely not

Table 3
Results of teachers' assessment of the inquiry activities

	Teachers' answers				
	a)	b)	c)	d)	e)
T1	42%	42%	16%	0%	0%
T2	4%	19%	77%	0%	-
T3	3%	10%	84%	3%	0%
T4	3%	29%	68%	0%	-
T5	0%	0%	97%	3%	-
T6	49%	32%	10%	3%	6%
T7	10%	13%	26%	32%	19%

We use the same structure of worksheets, the same methods of directed inquiry, the same lecturers, the same time constraints, and the same methods

of self-evaluation in every activity. Table 3 shows the responses of 100 teachers who undertook the evaluation of the 16 learning activities. The teachers evaluated the activities as stimulating and manageable with a standard class of students. The level of complexity of the worksheets is appropriate to the students' age range. The available activities are aimed at broadening the knowledge and skills of students, above and beyond school-level physics. Our aim was to motivate the teachers to acquire practical experience in inquiry-based learning, but most of the teachers prefer to leave the task of leading the student groups to the lecturers. The positive impact of the activities in the science centre on its application in the school environment is certainly praiseworthy.

Conclusions

Design-based research was used for the development and evaluation of a new educational activity on the level of guided inquiry. In order to manage guided inquiry, we use topics that are interesting from the point of view of the student, and that could be an educational challenge and a motivation for active research. Students work in groups according to the instructions in the worksheet provided, while trained instructors direct their work. At the end of the activity, the students formulate their findings based on their own measurements. The activities are focused on conceptual understanding and support the development of selected skills. The future lecturers, as well as the teachers following the course of the activity, gain valuable experience in conducting guided inquiry. The group of lecturers share their experiences and suggest improvements to the authors regarding materials and methodology. Once per semester, the whole team focuses on new topics suitable for the next period of training. School groups organised by science teachers are welcome to return to the centre again. If students are involved in guided inquiry activities a few times during their regular school classes, much better interaction during activities is evident and more positive feedback can be achieved. Thanks to the positive examples of the successful implementation of such activities, we are convinced that we are able to support IBSE in schools. However, the problem of educating teachers, their personal attitude towards using inquiry-based learning in their curricula, and the available support in terms of methods and work materials, remains unresolved.

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Practical School Experiments with the Centre of Mass of Bodies

Robert Repnik*[1] and Milan Ambrožič[2]

The concept of the centre of mass of a rigid body as a virtual point where the weight force acts is not easy to understand without a number of supporting school experiments. In school practice, however, experiments on this topic are often limited to a few of the simplest cases in which a simple flat body, such as a triangle or rectangle, is hung in two or mostly three directions to show where the corresponding plumb lines intersect. Typically, simple wooden bodies are used, on which the plumb lines are already drawn through the centre of mass. However, such experiments can be boring for students and are probably insufficient to illuminate all aspects of the topic. Furthermore, if the experiments are only demonstrated by the teacher rather than being performed in groups, the opportunity to train students' skills and develop nature-science competences is missed. We therefore prepared and performed a series of group experiments in logical sequence for students of the 8th and 9th grades of primary school, so that their full active participation was invoked. The experience with such an experiment setup with very simple equipment, together with the open discussion of results, increased pupil motivation for physics and perhaps also improved understanding of some physics problems regarding the centre of mass, even for younger students.

Keywords: centre of mass, practical school experiment, nature-science competences

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Priročni šolski poskusi s težiščem teles

Robert Repnik in Milan Ambrožič

Koncepta težišča trdnega telesa kot navidezne točke, v kateri je prijemališče teže, ni lahko razumeti brez večjega števila podpornih šolskih poskusov. Poskusi na to temo so v šolski praksi pogosto omejeni na nekaj najpreprostejših primerov s ploskimi telesi, kot sta trikotnik in pravokotnik, ki jih obesimo v dveh ali največ treh smereh, da bi poiskali točko, v kateri se sekajo težiščnice. Navadno se uporabi nekaj lesenih teles, na katerih so težiščnice že narisane, vendar pa utegnejo biti takšni poskusi za učence dolgočasni, poleg tega pa verjetno ne zadostujejo za osvetlitev vseh vidikov težišča. Če so poleg tega poskusi izključno demonstracijski, namesto da bi jih izvajali učenci sami po skupinah, učenci s tem izgubijo priložnost razvijanja spretnosti in naravoslovnih kompetenc. Zato smo pripravili in v šoli izvedli vrsto skupinskih poskusov za učence osmega in devetega razreda osnovne šole, pri čemer so bili učenci polno aktivni. Izkušnje s takšno postavitvijo poskusov in z odprto diskusijo rezultatov so pokazale povečano motivacijo učencev za fiziko in mogoče tudi boljše razumevanje nekaterih fizikalnih problemov v povezavi s težiščem, celo pri mlajših učencih.

Ključne besede: težišče, priročni šolski poskus, naravoslovne kompetence

Introduction

According to the national curriculum of Slovenia, the centre of mass is a topic that is taught within the subject of forces in the 8th grade of primary school (students aged 13 or 14), and later briefly in secondary school within the subject of forces and torques (students aged 15 or 16). In primary school, the level of understanding and the skill of determining the position of the centre of mass is limited to geometrical and non-geometrical bodies in two dimensions (2D). Subsequently, in secondary school, nothing essentially new is added to the topic of the centre of mass.

Acquiring the concept of the centre of mass in more detailed objects, particularly in real three-dimensional (3D) ones, is crucial for understanding several phenomena in nature and everyday life, such as: 1) stable and labile static equilibrium, 2) oscillation of a physical pendulum and its oscillation time, 3) rotation of rigid bodies in general, 4) complex movements of rigid objects composed of translational and rotational motion, etc. Of course, there are also practical applications of the understanding these phenomena; for example, in the case of the equilibrium of floating objects, such as ships.

In the authors' opinion, the usual experimental verification of the centre of mass of some simple flat bodies (mostly triangles, rectangles or trapezes) by hanging them on a string can be rather boring for students, particularly when only a few demonstration experiments are done by the teacher. This does not seem to develop the natural science competences of students very much. Several quite interesting experiments with 3D bodies (from simple bodies, such as a cube or tetrahedron, to more sophisticated shapes, achieved by merely combining and sticking together simpler objects) can be added to make the topic more attractive. Even using some other 2D objects can add sufficient interest; for example, a circular ring or an ellipse. In addition, such experiments can be done alone by students organised into groups. In this way, various other skills can be trained simultaneously, such as motoric and mathematical skills, not to mention the competences of interpersonal interaction, etc.

Our experiments support the inquiry-based activities that are desired and required in teaching nature-science subjects (DeBoer, 1991; Jones, MacArthur, & Akaygün, 2011). In connection with these requirements, the problem may arise that preservice teachers themselves have too little personal experience with the concepts of scientific work (Gabel, 2003; Newman, Abell, Hubbard, McDonald, & Martini, 2004). Inquiry-based education with the active participation of students has a positive effect both on acquiring a proper understanding of the scientific topic in question and on learning inquiry skills (Flick

& Lederman, 2006; Minner, Levy, & Century, 2010). This holds for students as well as for teachers. According to Šimenc, however, a great deal of time and effort is needed for the teacher to build his or her own inquiry skills and to apply them at school (Šimenc, 2008). Thus, meetings of the teacher and students with an active researcher with fresh ideas about any school topic can be extremely useful. Systematic research has indubitably shown a strong connection between the teacher's knowledge, scientific skills and the corresponding self-confidence in teaching science, on the one hand, and an increase in student motivation for science, on the other (Jarvis, Pell, & Hingley, 2011). Furthermore, inquiry-based learning can incorporate different learning styles according to the VARK model, i.e., visual, aural, read/write and kinesthetic/tactile (Fleming, 1995; Oblinger & Oblinger, 2005).

Group experimental work guided by the teacher, where the students try to solve specific experimental tasks alone and then verify and discuss the results in groups, can be attributed to the constructivist approach in teaching physics (Karič Merhar, 2008; Kline, 2010; Marentič Požarnik, 2004; Potočnik, 2004; Plut Pregelj, 2008). In the work of Kline, the success of the constructivist approach was compared (using tests of knowledge) with the traditional approach with some constructivist elements in the case of two physics topics in the 8th grade: pressure and buoyancy. It is interesting to note the findings: while there were no statistically significant differences in the success of both approaches in the case of the more elementary topic of pressure, the constructivist approach was proven to be more successful in the case of the more demanding topic of buoyancy. Other didactic research activities in Slovenia confirm the finding that the constructivist approach is particularly advantageous when the physics topic being taught is a synthesis of lower-level topics (Karič Merhar, 2008).

Science education and systematic motivation for science before the age of 14 is highly recommended in order to meet the need for scientists and technologists in the European society of knowledge (Osborne & Dillon, 2008; Pell & Jarvis, 2001). Furthermore, according to a UNESCO investigation (UNESCO, 1991), even young children seek to understand the fundamentals of the world; of course, often differently from the way the teacher presents such knowledge in school. Nevertheless, children's ideas might be of some use, and the teacher or expert should help them to find common meaning.

Thus, we prepared and performed a series of logically sequenced group experiments for primary school students. Our aim was to study the effects of these experiments on students' motivation and on their understanding of the concept of the centre of mass.

Research problem

Our aim was to determine how the implementation of a set of various experiments from the topic of the centre of mass, prepared for group work in school, influences:

1. student motivation,
2. acquiring a true understanding of the concept of the centre of mass.

In addition to the qualitative observations of the teacher or other performer of the physics workshop, a corresponding pre-test and post-test were also used in the study.

Methods

We first describe the experiments and their method of realisation. In some cases, but not all, we also performed some motivational frontal experiments. Due to the limited space in the present article, we will describe only the typical group experiments.

The experiments for determining the centre of mass can be divided into two types: 1) hanging a body on a string, and 2) pushing a body over the edge of a table. For the sake of brevity, we will call them "hanging" and "pushing" experiments, respectively. It is suggested to combine both types of experiments for all testing bodies, with an emphasis on pushing experiments. The bodies (objects) may be (approximately) two-dimensional (2D) bodies (such as a rectangle or triangle cut from paper), bodies made of thin sticks, three-dimensional (3D) bodies with the mass concentrated on the surface, etc.

The experimental requisites for the students' group experiments are: firm paper, scissors, pencils, pairs of compasses, rulers, a paper punch, thread or string, different weights, sticks, stands for hanging experiments, plasticine for connecting parts of objects, sticking tape, elastic bands (loops), spring balances, and paper clips for making small hooks.

The number of students in each group, sitting at the same desk with one experimental setup, was three or four. The students in each group were encouraged to divide their work at their discretion. Typical group experiments (among many other possible examples) are the following:

Experiment 1

The group performs an experiment with one of the wooden plates that have pre-drawn plumb lines through the centre of mass. They first push the object over the table slowly, with one of the drawn lines parallel to the edge of

the table (pushing experiment). They check whether the object falls when the plumb line with the centre of mass is aligned with the table edge. They may also check other directions, not drawn. This is a good opportunity to check the accuracy and precision of the students' work. Next, they hang the same object on a stand with a string (hanging experiment). They check whether all of the plumb lines are aligned with the string in the vertical direction.

Experiment 2

The group performs an experiment similar to the previous one using a ruler with a millimetre scale. The ruler is just a substitute for a rectangle. The motivation for this experiment is that the students guess and verify whether the ruler is a rectangle as an approximate 2D geometrical object.

Experiment 3

The group cuts different 2D objects out of cardboard or firm paper (hereinafter referred to merely as "paper"). The objects can be more or less symmetrical: triangle, rectangle, circle, circular ring, etc. (Figs. 1 and 2). The students again perform both types of experiments to determine the centre of mass. This time, they use pencils and rulers in the pushing experiments to draw the corresponding plumb lines. For the subsequent hanging experiments, some small holes should be made near the edges of the paper objects using a paper punch. In addition, the students can do similar experiments with an object with no symmetry at all. For instance, we prepared the outlines of maps of Slovenia and Croatia, with a size of approximately 15 cm in one of the directions. The maps were obtained from the Internet, printed on normal paper, stuck onto firm paper and then carefully cut out. This may also be a useful exercise for student homework.

Figure 1. Some pushing experiments involving determining the plumb lines of cardboard objects.

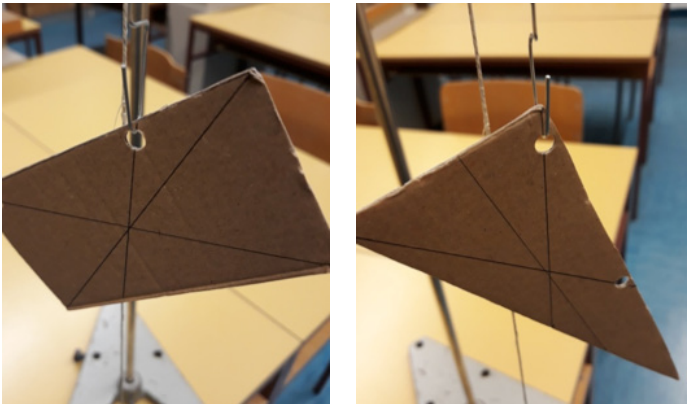

Figure 2. Some hanging experiments using the same objects as in the pushing experiments. In this case, the string was not completely stretched because the paper objects were not heavy enough relative to the hanging string; therefore, a parallel string with a heavier hanging object (e.g., a ruler) was used so that the student could compare the true vertical alignment of the plumb lines.

Experiment 4

Students can execute a pushing experiment with a ruler and a weight with a comparable mass. Since the weight has a known mass, the students use a spring balance (newton meter) to measure only the unknown mass of the ruler. They place the weight on the ruler at one of the ends, and then execute a pushing experiment (Figure 3). They can try two variants: the weight can be positioned at the end of the ruler that rests on the table, or it can be positioned at the end that extends beyond the table. The students are encouraged to note down the data and, by themselves as homework, try to find a quantitative relation between the lengths and masses.

Figure 3. A pushing experiment with a ruler and a small weight (left), and with a tetrahedron cut from paper (right). In the experiment on the left, the ruler was slowly pushed along its length over the edge of the table, so that the weight on the ruler was increasingly near the edge.

Experiment 5

The paper can also be used to make the faces of different geometrical bodies, such as a cube or a regular tetrahedron (Figure 3, right). It is a good exercise for the students to determine (or remember) how to make such a connected surface skeleton from just one piece of paper. After the skeleton is cut out, the side faces can be stuck together using sticking tape, with their edges together. Since it is difficult to determine the centre of mass of 3D bodies in a practical way, the pushing and hanging experiments are done only to get a qualitative feeling of the position of the centre of mass, and perhaps to guess its exact location.

Experiment 6

Skeletons of 3D geometrical bodies, such as cube or tetrahedron, can also be made with the use of sticks fastened together with plasticine or similar. However, the students should be aware (the teacher must pay particular attention to this fact) that the distribution of mass is very different in the case of "full" bodies, their surface skeletons (as in the previous paragraph), and their edge skeletons (as in this paragraph).

Experiment 7

This experiment was performed qualitatively or quantitatively. A ruler (or perhaps two rulers fastened together with an elastic band to double the length) is hung on a stand. This could be done easily, because our rulers had small holes near one end. The ruler was moved slightly from equilibrium and allowed to oscillate. The oscillation time was measured with a wristwatch or smartphone, or just roughly estimated.

Methods

The effect of the proposed experiments on the students' critical reasoning, as well as on their attitude to science, is evaluated by different means, depending on the circumstances. The cooperation and motivation of students during experiments is valuable information, but only on a qualitative basis. For a more quantitative evaluation of the success of our didactic strategy, we use a corresponding pre-test and post-test, which are presented in the Appendix.

Sample

Four different research samples were studied in 2017, all involving different ages, event occasions, workshop durations and test examinations: 1) at the end of May, at the final gathering that concluded the lecturing year for young students (Mini University of the Faculty of Arts – MUF) held at the Faculty of Arts, University of Maribor; 2) at the beginning of June, at a study camp for gifted pupils at the Paški Kozjak Primary School; 3) and 4) in September, in regular 9th grade classes at two primary schools (denoted simply S1 and S2) in two different regions of Slovenia. The numbers of the experiments listed above (performed either partially or entirely) will be given separately for each sample.

*MUF **(Mini University of the Faculty of Arts)***

The MUF is a "university for children", where scientists from different faculties of the University of Maribor try to encourage the interest of primary school students in science and scientific questions, including the area of natural sciences, among them physics. The teaching level and language is adapted to the age of the participants. The main audience in the concluding gathering of the MUF was pupils from the 4th to the 8th grade, as well as their parents. All of the experiments were frontal, and there was no pre-test or post-test. Performed experiments: 1, 2, 4 and 7.

Paški Kozjak

Four primary schools from Slovenian Carinthia have established a traditional annual meeting towards the end of the school year. It is a two-day camp for gifted students from the 6th to the 9th grade, with a workshop on various subjects running simultaneously. This year, eight students chose the physics workshop, which lasted about three school periods (three times 45 minutes or slightly longer). The students were divided into two groups of four, each with the same experimental equipment (Figure 4). There was no pre-test or post-test, just short open discussions of the results of the experiments. Here, the constructivist approach was adopted in full, as enough time was available. Performed experiments: all experiments from 1 to 7.

Figure 4. Group experiments about the centre of mass at Paški Kozjak.

Primary school S1

The workshop was executed with two 9th grade classes in a row (a total of 17 students, with both valid tests given). For each class, the workshop lasted 45 minutes, as it was performed as a regular physics lesson. The students were divided into groups of three or four, each with the same experimental equipment. The pre-test and post-test were given (each lasting five minutes), so there was only 35 minutes remaining for experiments. Performed experiments: from 2 to 5.

Primary school S2

The workshop was executed with three 9th grade classes in a row (a total of 51 students, with both valid tests given), and the workshop lasted 75 minutes for each class. The group work and the experimental setup and equipment were similar to those used in sample S1. The physics workshop was part of a technical day with two other simultaneous workshops (so the three classes rotated in three workshops). A short description of the workshops with some photographs is available on the school web page (Solkan Primary School, 2017) listed in the references below. As in the case of S1, the pre-test and post-test were given (each lasting five minutes), so there were still 65 minutes available for experiments. Based on the authors' previous experience (difficulties encountered by students of S1 in answering some questions) the post-test was modified slightly for S2. Performed experiments: from 1 to 6.

Results and interpretation

Due to the different workshop conditions for the different sample groups, the results are given separately.

MUF

One of the authors presented a short simplified talk (roughly 15 minutes) about the centre of mass, together with demonstration experiments. Of course, the time was too short and the students too young to perform all of the experiments described above, but some other suitable experiments were executed. The author invited four students to cooperate in the experiments. The experiments demonstrated included hanging experiments with maps of Slovenia and Croatia, a pushing experiment with a ruler, the oscillation of the ruler or two connected rulers as a physical pendulum, etc. According to the author's experience and the feedback after the demonstration, all of the children as well as their parents in the audience were quite interested in the experiments.

Paški Kozjak

Based on the observations of the author, we mention the following. The experiments were executed with no special difficulties. There was enough time for all of the experiments listed above. The students were interested in the experiments and showed a good level of manual skills; for example, they quickly determined how to construct the surface skeleton for the tetrahedron, once the author had shown them how to construct the simplest body, the equilateral triangle. A few of the students demonstrated good physics intuition regarding topics not even taught in primary school physics.

Primary school S1

Many of the students forgot to identify themselves with the same code on both tests (or were not focused enough to solve the post-test), which is why there were only 17 valid pairs of pre-test and post-test results. The experiments involving determining the centre of mass both by pushing and hanging were executed on the following objects cut from paper: rectangle, triangle, circle, circular ring, cube and tetrahedron surface. Based on the author's experience, 35 minutes (including the time required for the students to sit down and receive some formal information from the teacher) is far too short a time to perform the series of the experiments carefully. There was no frontal explanation of the results of experiments, just casual comments between the experiments (the same was true for sample S2 below). The results of the tests are shown in Tables 1 to 3.

Primary school S2

All of the students identified themselves correctly with the same code on both tests, as there was no hurry to finish the lesson and go to the next classes, as was the case at school S1. Based on the author's experience, 65 minutes is just adequate to perform the series of experiments with adequate descriptions.

The results of the tests are shown in Tables 1 to 3 and in Figure 5. The following symbols will be used in the discussion below: P_{Ii} (initial points, i = 1 to 5) is the number of points achieved in the i-th question and for the individual student in the pre-test; P_{Fi} (final points, i = 1 to 5) is the corresponding result in the post-test; and $D_i = P_{Fi} - P_{Ii}$ is the corresponding difference between the tests (see Figure 5).

Table 1

The mean number of points per question for each school separately

Question	Max. points	S1 (17 valid pairs)		S2 (51 valid pairs)	
		Pre-test	Post-test	Pre-test	Post-test
Q1	1	.18	.29	.69	.69
Q2	2	.88	-.18	.96	1.08
Q3	1	-.65	-.35	.00	.49
Q4	2	1.06	1.24	1.43	1.37
Q5	1	.65	-.53	.37	.39

Note. $\langle P_{Ii} \rangle$ for the pre-test and $\langle P_{Fi} \rangle$ for the pre-test. For instance, $\langle P_{Ii} \rangle$ = .18 and $\langle P_{Fi} \rangle$ = .29 for S1, etc. The second column shows the maximum number of possible points for each question = the number of correct answers shown in the Appendix.

Table 1 shows the average number of points achieved for two samples, for both tests and for each question separately. A negative mean result means that more than half of the students gave the wrong answer (in the case of only one answer chosen). Therefore, a zero mean value denotes the success of half of the sample in answering the question (see the explanation for evaluating the tests in the Appendix). Except for the last question, the results of the pre-test are better for sample S2 than S1. It is somewhat surprising that the results in questions Q2 and Q5 of the post-test for sample S1 are so much worse than in the pre-test. Perhaps the students were slightly confused at the end of the lesson due to the hurry and the number of experiments. The students from school S2 obviously obtained better average results in all of the post-test questions than those from S1, particularly in Q2 and Q5. The two most probable reasons for

this are: 1) the students of S2 had more time and were in less of a hurry, 2) the post-test questions for S2 were changed due to the poor results of S1 students, and therefore probably easier (the differences are mentioned in Appendix A).

SPSS software was used to reveal some differences on a solid statistical basis. The Mann-Whitney *U* test was used, which works well for non-Gaussian distribution and for very different sizes of compared samples (in our case 17 and 51). In the first statistical test, the differences D_i were compared for both schools and for each question. The test revealed significant differences between S1 and S2 only for questions Q2 and Q5 (as expected from Table 1): for Q2 $U = 263.5$ with $P = 0.002$ (2-tailed asymp.sig.), while for Q5 $U = 255.0$ with $P = 0.005$ holds. For the other three questions, the differences D_1, D_3 and D_4 were not significant for S1 and S2; it is true that the results of the post-test were better in the case of S2, but so were the results of the pre-test. In the second Mann-Whitney *U* test, only questions Q2 and Q5 were treated, but separately for the pre-test and the post-test. Again, differences in results for both schools were analysed. The entire table (Tables 2 and 3), obtained from SPSS is given below.

Table 2
Mann-Whitney U test – ranks (SPSS)

Query	School	*N*	Mean rank	Sum of ranks
Q2 pre-test	S1	17	34.50	586.50
	S2	51	34.50	1759.50
	Total	68		
Q2 post-test	S1	17	**21.26**	361.50
	S2	51	**38.91**	1984.50
	Total	68		
Q5 pre-test	S1	17	38.32	651.50
	S2	51	33.23	1694.50
	Total	68		
Q5 post-test	S1	17	**25.53**	434.00
	S2	51	**37.49**	1912.00
	Total	68		

Table 3
Mann-Whitney U test – statistics (SPSS)

	Q2 pre-test	Q2 post-test	Q5 pre-test	Q5 post-test
Mann-Wh. *U*	433.5	**208.5**	368.5	**281.0**
Wilcoxon W	586.5	361.5	1694.5	434.0
Z	.000	-4.293	-1.160	-2.499
Asymp. sig.	1.000	**.000**	.246	**.012**

While there were no statistically significant differences between both schools in solving pre-test questions Q2 and Q5, the corresponding post-test questions were answered significantly better by the students of S2 (bold numbers in Tables 2 and 3; see also Table 1 for averages). Therefore, the post-test was the main contribution to test differences D_2 and D_5. The most probable explanation for this difference is that the students from S1 had too little time available, as mentioned above. But why just questions Q2 and Q5? Because they seem to be slightly more difficult than the other questions. Finally, we should mention the results regarding Q3. It is surprising that such a difference between the schools in the pre-test is evident in Table 1. Among the incorrect answers to this question, the answer that the mountain has its centre of mass at half-height was chosen most often (see Appendix).

Since there were 51 students with valid pre-tests and post-tests in sample S2, we can also present the results for individual students and for each question separately as the difference D_i between the points achieved in the post-test and the pre-test. The corresponding histograms for questions Q2 and Q5 are shown in Figure 5. The histograms were verified for other questions, as well, but no particular differences were determined. It should come as no surprise that the presented histograms are not very similar to Gaussian histograms; firstly, the sample is small, and secondly, the differences D_i can only have a few integral values.

Figure 5 shows that most of the students received the same number of points for each question in the post-test and the pre-test ($D_i = 0$). The same holds for the other three questions. This is in accordance with small differences of mean values for both tests in Table 1. This does not mean that experimental group work of this kind is inefficient; we must bear in mind that the students had already attended lectures about the centre of mass in 8th grade physics. Furthermore, in the authors' opinion, the post-test should be done later, in a separate physics lecture, if possible. Most probably, the impressions about the experiments take time to settle in the students' memory, and some additional

explanation from the teacher would also be useful. We have recommended this to current physics teachers, in case they intend to repeat similar experiments themselves.

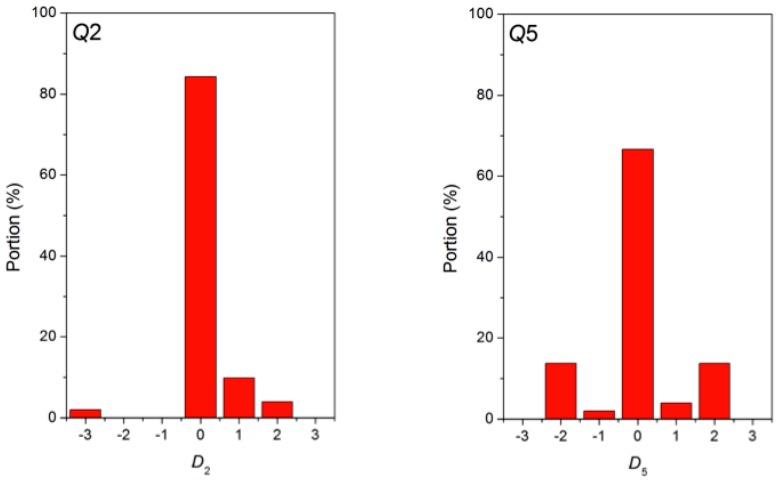

Figure 5. The histograms of the test differences D_2 and D_5 for individual students in sample S2. The vertical axis corresponds to the portion of students as percentages.

Among additional qualitative observations, with regard to the 9th grade primary school samples, it was observed that some aspects of geometrical knowledge and skills, e.g., about using the pair of compasses to draw a regular triangle, had been forgotten. Therefore, such experiments are also valuable for maintaining various mathematical skills. Ambrus discusses various aspects of the relationship between the mechanisms of mind and more successful teaching/learning of mathematics (Ambrus, 2014). Among the interesting points in his article relevant to our work, we mention the following:

1. The mind uses metaphors to facilitate memorising, and abstract ideas are represented by concrete examples.
2. Besides audial and visual information channels, we should also use the motoric/tactile memory, which is very accurate: about 90% of the content of what is done or spoken aloud is remembered.
3. Closed problems should sometimes be transformed into open ones.

This is exactly what was done to relate at least some of the physics experiments regarding the centre of mass with geometry in a mathematical sense.

We should also stress the most crucial difference between the experiments denoted by numbers 1 and 3 above: while the plumb lines are already drawn in experiment 1, the students draw the plumb lines themselves in experiment 3. We suggest that if teachers do not have enough time to execute all of the above experiments in school, they should choose the group experiments in which the students determine and draw the plumb lines themselves (perhaps on pre-prepared plastic objects from which pencil lines can be easily erased after the lecture). This is more fun and better for the development of the students' competences than just verifying pre-drawn plumb lines.

Conclusions

According to our experience, the implementation of the group experiments described regarding the centre of mass demonstrated that the motivation was very high for all of the research samples listed above. Although it is impossible to measure the development of different skills in such a short period, it was observed that the motor skills of individuals in the groups were satisfactory. Geometrical reasoning was also good, although a few details from lower grade lectures had been forgotten.

For a more systematic investigation of the success of the experiments discussed above, we suggest that, over a period of at least a few years, the tests should be undertaken in the 8th grade, when the centre of mass is treated in physics lessons. We recommend reserving two lessons for this topic. These do not necessarily have to be physics lessons; physics can be combined with mathematics or technical studies. This can be arranged simply if the same teacher teaches both physics and mathematics, for instance; otherwise, two teachers should cooperate. If the teacher repeats this series of experiments a few years in a row and compares the qualitative observations with control groups (i.e., a class where something else is done in connection with this physics topic), he or she should be able to determine the usefulness of the proposed experiments.

Several modifications of the described group experiments can be made; for example, a smartphone camera could be used in the pushing experiments with objects cut out of paper, and the plumb lines could thus be determined on photographs. It would be interesting to compare the measurement accuracy if different student groups used different experimental approaches. The teacher could decide to prepare paper skeletons of some 3D objects alone prior to the lesson. It might also be a good exercise for students to discuss the sources of the measurement/preparation error of such objects as compared to ideal geometrical objects (the effect of glue, sticking tape, etc.).

Appendix: Pre-test and post-test

More than one correct answer is possible for some questions, and the students were warned about this. Correct answers in the tests below are marked with a plus sign (+). In aggregating the points, each wrong answer chosen results in one negative point, while each correct answer chosen results in one positive point. The students were intentionally not informed about this evaluation system. Below, we present the pre-test (the same for S1 and S2) and the post-test for S2 only.

The questions in the pre-test were as follows:

1. Where is the centre of mass of a human being?
   a. In the head.
   b. In the chest.
   c. In the stomach. +
   d. Between both knees.
   e. In both feet.
2. Where is the centre of mass of a rectangle?
   a. Halfway along the longer side.
   b. Halfway along the shorter side.
   c. At one of its vertices.
   d. At the intersection of its diagonals. +
   e. At the intersection of the symmetry axes of the sides. +
3. Where approximately is the centre of mass of a mountain?
   a. At its top.
   b. At its bottom at ground level.
   c. At half height.
   d. Below half height. +
   e. Above half height.
4. Which claims are true?
   a. If more than half of the length of a ruler is pushed over the edge of a desk, the ruler stays on the desk (the ruler is perpendicular to the edge).
   b. When a ruler is pushed over the edge of a desk, the ruler stays on the desk when more than half of its length rests on the desk (the ruler is perpendicular to the edge). +
   c. A book stays on the desk when it is pushed over the edge, but the side diagonal that is parallel to the edge remains on the desk. +
5. When a concentric circle with a smaller radius is cut out of a full circle made of paper, what happens to the position of the centre of mass?

a. The centre of mass disappears, since the centre of the ring is in the hole.
b. The centre of mass is still in the geometrical centre. +
c. The centre of mass moves so that it is somewhere in the body of the ring.

The questions in the post-test were as follows:

1. Where is the centre of mass of a human?
   a. In the brain.
   b. In the lungs.
   c. Under stomach and liver. +
   d. Between both knees.
   e. In both feet.
2. Where is the centre of mass of a rectangle?
   a. Halfway along the longer side.
   b. Halfway along the shorter side.
   c. At one of its vertices.
   d. At the intersection of its diagonals. +
   e. At the intersection of the symmetry axes of the sides. +
3. Where approximately is the centre of mass of a pyramid (with the base on the ground)?
   a. At its top.
   b. At its bottom at ground level.
   c. At half height.
   d. Below half height. +
   e. Above half height.
4. Which claims are true?
   a. If more than half the length of a ruler is pushed over the edge of a desk, the ruler stays on the desk (the ruler is perpendicular to the edge).
   b. When a ruler is pushed over the edge of a desk, the ruler stays on the desk when more than half of its length rests on the desk (the ruler is perpendicular to the edge). +
   c. A book stays on a desk when it is pushed over the edge, but the side diagonal that is parallel to the edge remains on the desk. +
5. From a square made of paper, we cut a smaller square with parallel sides so that their centres coincide. Where is the centre of mass of the figure/frame?
   a. The figure does not have a centre of mass, since it should be in the hole.
   b. In the common centre of both squares. +
   c. Outside the square hole, but inside the figure.

We should mention that some of the post-test questions for sample S1 obviously proved to be more difficult than assumed. For instance, Q1 was

expressed in height for a man with the height of 180 cm. Q5 supposed a sphere with a cut-out smaller sphere instead of a square. The results of the students from S1 in answering this question were much worse than the corresponding question in the pre-test. It seems that, in this case, transforming the problem from 2D to 3D requires a significant mental leap.

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Taxonomy of Teaching Methods and Teaching Forms for Youth in Non-Formal Education in the National Youth Council of Slovenia

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Research from the field of non-formal education (NFE) in youth work emphasises the central role of experiential learning and learning in groups. The present paper aims to research teaching methods and teaching forms in NFE in youth work. The research sought to answer the following research questions: 'What teaching forms can be found in NFE for young people in youth councils on a national level in Slovenia?' and 'What teaching methods can be found in NFE for young people in youth councils on a national level in Slovenia?' Data was collected using semi-structured interviews; the instrument was a list of questions. The empirical research was conducted in July 2016 with six interviewees. The results indicate that learning in selected NFE in the National Youth Council of Slovenia (MSS) is participatory, interactive, inclusive and student-focused; with central concepts of experiential learning and learning in groups. The key teaching form is learning in groups. However, individual work, work in pairs, programmed instruction and direct instruction are also present. The central and omnipresent teaching method is experiential learning. Problem-based learning, case-study method, action learning, and project-based learning are intertwined and connected to the experiential learning method. Other methods include verbal-textual methods, illustrative-demonstration methods, experimental methods, peer learning, and support methods. The conclusions are applicative in the didactic spectrum of NFE in youth work and in the wider didactic spectrum of adult learning. Implications for further research include teaching methods and forms in NFE inside the wider youth sector, internationally comparative and through quantitative research.

Keywords: non-formal education, teaching forms, teaching methods, youth organisations, youth work

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Taksonomija učnih metod in oblik za mlade v neformalnem izobraževanju v Mladinskem svetu Slovenije

Vesna Miloševič Zupančič

Raziskave s področja neformalnega izobraževanja (NFI) v mladinskem delu poudarjajo osrednjo vlogo izkustvenega učenja in dela v skupinah. Cilj tega prispevka je raziskati učne metode in oblike v NFI v mladinskem delu. Raziskava je poskušala odgovoriti na naslednji raziskovalni vprašanji: »Katere učne oblike obstajajo v NFI za mlade v mladinskih svetih na nacionalni ravni v Sloveniji?« in »Katere učne metode obstajajo v NFI za mlade v mladinskih svetih na nacionalni ravni v Sloveniji?«. Podatki so bili zbrani s pol-strukturiranimi intervjuji, pri čemer je bil instrument seznam vprašanj. Empirična raziskava je bila izvedena v juliju 2016 s šestimi intervjuvanci. Izsledki kažejo, da je učenje v izbranih NFI v Mladinskem svetu Slovenije (MSS) participativno, interaktivno, vključujoče in osredinjeno na učenca – z osrednjimi koncepti izkustvenega učenja in dela v skupinah. Osrednja učna oblika je učenje v skupinah. Prisotne pa so tudi druge posredne učne oblike: individualno delo, delo v dvojicah in programirani pouk ter neposredna oz. frontalna učna oblika. Prevladujoča in vseprisotna učna metoda je izkustveno učenje. Problemska metoda, metoda primera, akcijsko učenje in projektna metoda so prepleteni in se povezujejo z izkustvenim učenjem. Preostale metode vključujejo verbalno-tekstualne metode, ilustrativno-demonstracijske metode, laboratorijsko-eksperimentalne metode, vrstniško učenje in podporne metode. Zaključki so aplikativni v didaktičnem spektru NFI v mladinskem delu in širšem didaktičnem spektru izobraževanja odraslih. Predlogi za nadaljnje raziskovanje vključujejo učne metode in oblike v NFI znotraj širšega mladinskega sektorja, primerjavo na mednarodni ravni in dopolnitev s kvantitativno raziskavo.

Ključne besede: neformalno izobraževanje, učne oblike, učne metode, mladinske organizacije, mladinsko delo

Introduction

Subjective perceptions of learning might bring the first association to the learning in the formal educational system, referred to as formal learning. However, youth organisations are places that offer young people the other two categories of learning: non-formal learning and informal learning. Non-formal education (NFE) and training together with boosting the competencies of young people are within the key scopes of organisations in the youth sector.

The field of youth work is highly interdisciplinary, connecting several scientific disciplines, including pedagogy, social work, and political science. The concept of youth work is polyvalent, multifaceted, heterogeneous, and has no unified definition (Coussée, 2009; Pantea, 2012). It can be described as a reaction to the processes of exclusion, alienation, and disintegration of modern societies (Kuhar & Razpotnik, 2011). In Slovenia, youth work can be defined as a form of work with young people, which is voluntary, encouraging active citizenship, fostering social integration and consciously containing educational components (Kuhar & Leskošek, 2008). Youth organisations are civil society organisations that are non-profit, private, and formal. As such, they can be located in the part of social reality between the community, the state, and the market (Kolarič & Rakar, 2010). It is said that the role of citizens and civil society shall be reconsidered in an attempt to widen democratic participation (Gaber & Mojškerc, 2014). The majority of Western democracies encourage youth participation as a part of the debate on modern citizenship (Bessant, 2004), the result of which is the formation of youth councils, youth assemblies, and other decision-making or consulting bodies (Taft & Gordon, 2013). Rakar et al. (2011) divide youth organisations in Slovenia, among others, into the National Youth Council of Slovenia (MSS), youth councils of local communities, youth centres, national youth organisations, and other non-governmental organisations.

There are both non-formal learning and informal learning in youth organisations (European Commission, 2000, 2012). Learning is a broad concept, defined by several theories in psychology (Marentič-Požarnik, 2014), sociology (Haralambos & Holborn, 2005) and other disciplines (e.g., economy), with the official definition by UNESCO/ISCED (Marentič-Požarnik, 2014, p. 10–19; UNESCO, 1993, p. 2). Regarding the situation in which learning takes part, we can divide learning into three categories (Žagar & Kelava, 2014). Formal learning is a highly institutionalised and structured process; informal learning is an activity that takes place in everyday life (Boeren, 2011), it is not institutionalised, and it can be self-, family- or socially-directed (Lebeničnik, Pitt, & Starčič Istenič, 2015). Lastly, non-formal learning can be defined as 'organized

education taking place outside the formal education system' (Boeren, 2011, p. 335). It can *inter alia* take place within civil society organisations such as youth organisations (European Commission, 2000).

Within the concept of learning, the present paper focuses on a didactic aspect, on teaching methods and teaching forms.[2] Teaching methods can be defined as theoretically justified and empirically tested modes of action, through which the subjects of the educational/learning processes implement their aims and objectives (Kramar, 2009). Modern didactics and educational psychology divide them into student-focused and teacher-focused methods (Radovan, 2013). Teacher-focused methods emphasise information transmission, whereas student-focused methods emphasise the conceptual change (Stes & Petegem, 2014). Constructivist theories of learning emphasise the shift in focus from conventional lectures to teaching methods that activate the learner and are student-focused (Struyven, Dochy, & Janssens, 2010). Active teaching methods include case-study, problem-based learning, collaborative assignments (Struyven et al., 2010), participatory learning, experiential learning, peer learning, and project-based learning (Javornik Krečič, Rutar Leban, & Kelava, 2014). Problem-based learning is defined as learning where students work in groups to resolve complex, real(istic) problems under guidance (Allen, Donham, & Berhhard, 2011), and it is considered more interesting and efficient than classic academic presentations (Gojkov, Stojanović, & Gojkov-Rajić, 2015). Similarly, project-based learning can be defined as learning in groups under guidance to research and create projects (Bell, 2010). The cognitive-constructivist model overcomes the division of teacher-focused and student-focused methods, thereby stressing the construction of knowledge in the interaction between both sides (Javornik Krečič et al., 2014). The teaching process is a communication process by its nature; therefore, teaching methods can be classified according to the source by which the message comes to the learner (Tomić, 2000). Classification by the source divides teaching methods into the verbal-textual method (spoken explanation method; conversation method; working with texts), the illustrative-demonstration method, the experimental method, and the experiential learning method (according to Kolb) (Tomić, 2000). Based on Jarvis, experiential learning originates in primary experiences, and it can be defined as learning through activity, which differentiates it from passive

2 The concept of teaching methods is often semantically broader in the context of English-speaking countries and it includes the notions of teaching forms. However, in the German-speaking countries (e.g., Germany) and in countries of ex-Yugoslavia (e.g., Slovenia, Croatia), there is a division in didactics to teaching methods and teaching forms. As the paper aims to encompass all the didactic aspects of NFE in youth organizations in the geographical context of Slovenia, the author follows the division of teaching methods and teaching forms.

learning through the reception of information (Timm, Birkenmaier, & Tebb, 2011). Kolb's experiential learning is based on a circular model with four phases: concrete experience, reflective observation, abstract conceptualisation, and active experimentation (Timm et al., 2011). Kramar (2009) divides methods by functionally-complementary perspective, as Tomić does, with the exception of experiential learning, which he omits. He further classifies methods to the spoken explanation method, lecture, conversation method, textual method, demonstration method, problem method, and case method. The classification of Starc, Rodica and Konda (2015) is a combination of Kramar's and Tomić's models, with some methods bearing the same semantic meaning but named differently (e.g., laboratory method vs. experimental method); therefore, the only addition is the project method. Other authors (Brook, Pedler, & Burgoyne, 2012; Ivon & Kuščević, 2013; Mijoč, 1995, 2007, 2009) mention action learning, project method, case-study method, experiential learning, role-play, simulation, structured practice, group interaction, and guided visualisation.

Furthermore, teaching forms can be defined as social forms in which the learning process, that is teaching and learning, takes part (Tomić, 2000). Teaching forms in the German context can be divided into frontal teaching/direct instruction, group work, work in pairs and individual work (Garotti, 2015; Jank & Meyer, 2006; Kiper, Meyer, & Topsch, 2002). Authors in didactic theory classify them into frontal teaching form/direct instruction and indirect form/autonomous work of students (Kadum-Bošnjak, 2012; Kramar, 2009; Strmčnik, 2001; Tomić; 2000). The indirect form consists of learning in groups/group work, work in pairs and individual work (Kramar, 2009; Rot Vrhovec, 2015; Starc et al., 2015; Strmčnik, 2001; Tomić, 2000; Topolovčan, 2012). Group work, and thus participation in group activities, is the primary form of teaching in NFE (Eraut, 2004 & Wenger, 1998, in Kiilakoski & Kivijarvi, 2015). Some authors (Javornik Krečič et al., 2014; Stanković & Blažić, 2015) add programmed instruction, which runs without direct instruction, mostly as individual work. Teaching methods and forms are necessary not only for the diversification of education, but also to achieve deeper understanding and independent, critical and creative learning (Javornik Krečič et al., 2014). It is believed that the choice of teaching forms and methods (e.g., more practical learning, omitting *ex-cathedra*) might even improve the learner's career success (Pavlin, 2014).

Prevailing methods and forms of teaching in youth organisations are peer learning, experiential learning (Bužinkić, Ćulum, Horvat, & Kovačić, 2015; del Felice & Solheim, 2011), interactive and participatory learning, and learning in groups (Fennes & Otten, 2008). Participative learning is defined as learning that recognises and values experience (Sapin, 2009); as an approach in adult learning

that encompasses three components: using participants' experiences as a basis for learning, valuing these experiences throughout the programme, and encouraging participants to learn from each other (Sapin & Waters, 1990). Methods that are classified as appropriate in the spectrum of youth work are active learning, experiential learning, learning from each other/participatory learning, passing on information and illuminating (Sapin, 2009). In youth organisations, young people learn through workshops, trainings, debates etc. (Souto-Otero, 2016). They learn through the methods of NFE on planned trainings, from guidance of experienced workers, from educational materials, in learning-by-doing, and though the aforementioned peer learning and experiential learning (Del Felice & Solheim, 2011). Beside NFE, young people also learn through informal learning, which is perceived as spontaneous learning, mostly based on interaction with peers outside of planned activities (Del Felice & Solheim, 2011).

There is a plethora of research on teaching methods and forms (Allen et al., 2011; Bell, 2010; Brook et al., 2012; Garotti, 2015; Gojkov et al., 2015; Ivon & Kuščević, 2013; Jank & Meyer, 2006; Javornik Krečič et al., 2014; Kadum-Bošnjak, 2012; Kramar, 2009; Kiper et al., 2002; Mijoč, 1995, 2007, 2009; Radovan, 2013; Rot Vrhovec, 2015; Stanković & Blažić, 2015; Starc et al., 2015; Stes & Petegem, 2014; Strmčnik, 2001; Struyven et al., 2010; Timm et al., 2011; Tomić, 2000). It is acknowledged that there are learning processes, non-formal learning and NFE taking place in youth work inside youth organisations (European Commission, 2000, 2012; Fennes & Otten, 2008; Kuhar & Leskošek, 2008; Souto-Otero, 2016). Furthermore, some studies illuminate the field of teaching methods and teaching forms in youth organisations (i.e., Bužinkić et al., 2015; del Felice & Solheim, 2011; Fennes & Otten, 2008; Sapin, 2009; Souto-Otero, 2016). However, there are gaps in the detailed research of teaching methods and forms in Slovenian youth organisations/youth councils.

Primary objective

The present paper explores the didactic aspects of NFE in youth work. It aims to contribute to a better understanding of teaching methods and teaching forms in NFE in national youth councils in Slovenia. The objective is to prepare the taxonomy of NFE on a national level that is conducted by qualified educators and carried out in national youth councils in Slovenia.

Research questions

The following research questions guided the research:

- What teaching forms can be found in NFE for youth in youth councils on a national level in Slovenia?

- What teaching methods can be found in NFE for youth in youth councils on a national level in Slovenia?

Research methodology

Research sample

- Population: all NFE for youth in youth councils on a national level and in youth councils on a local level.
- Sample: selected NFE for youth in youth councils on a national level.
- Selection criteria of NFE: duration (more than one day), date of NFE (last conducted NFE), level (national), competence of educators (qualified for conducting NFE in youth sector).

There was only one youth council on a national level at the time of the research: *Mladinski svet Slovenije*, National Youth Council of Slovenia (MSS). It is defined in legislation (Act Amending Youth Councils Act, 2010; Youth Councils Act, 2000) as a voluntary association of national youth organisations, which have a status of an organisation in the public interest in the youth sector in accordance with the act (Public Interest in Youth Sector Act, 2010). One of the policy areas of MSS is youth work. NFE and training together with the enhancement of competencies are among the main objectives.

According to the selection criteria, the selected NFE is *Usposabljanje za trenerje v mladinskem delu* (Training for Trainers in Youth Work) that took place between March 31st and April 3rd, 2016 in Brežice, Slovenia. It was described as an intensive four-day training. There were 23 participants and four educators, known as trainers. Their aim was to train the participants for preparation, execution and evaluation of trainings in youth work and to prepare them for working with young adults.

Data collection (methods)

- The research paradigm: qualitative.
- Data collection technique: semi-structured interviews.
- Instrument: the list of questions for semi-structured interviews.

The list of questions was peer-reviewed by an expert and based on a synthesis of several models. The classification of the teaching methods was synthesised by Allen et al., 2011; Bell, 2010; Brook et al., 2012; Ivon & Kuščević, 2013; Kramar, 2009; Mijoč, 2007; Timm et al., 2011; Tomić, 2000; Starc et al., 2015. The classification of teaching forms was synthesised by authors Garotti, 2015;

Jank & Meyer, 2006; Javornik Krečič et al., 2014; Kiper et al., 2002; Kramar, 2009; Rot Vrhovec, 2015; Stanković & Blažić, 2015; Starc et al., 2015; Strmčnik, 2001; Tomić, 2000; Topolovčan, 2012. The list of questions was divided into four sections, and it comprised 19 questions, with sub-questions.

Participants

For a better understanding of the problem and for validity and reliability purposes, the interviews were conducted with the same instrument on three different groups of persons (three sources of data); that is with data source triangulation (Easterby-Smith, Thorpe & Lowe 2007; Devetak, Glažar, & Vogrinc, 2010; Vogrinc 2008). The three groups of interviewees are presented in Table 1. Persons were selected by the time criterion, namely those who responded to the invitation first. The number of interviews was determined by the rule of theoretical saturation (Flick, 2006), which is the reason for a difference between the planned number of interviews and the number of conducted interviews as seen in Table 1.

Table 1
Participants of the research – interviewees

Level	Planned no. of Interviews	No. of conducted interviews	The position of interviewees
Organiser	1–2	2	1 person, responsible for NFE at MSS 1 person, responsible for educating trainers at MSS
Trainer	1–2	2	2 persons, qualified for conducting NFE in youth sector by MSS criteria, who were trainers at the last NFE event on a national level at MSS, which lasted more than 1 day
Participant	2–3	2	2 persons, who were participants at the last NFE event on a national level at MSS, which lasted more than 1 day and was conducted by qualified trainers

Research conduct

- Data collection period: between 14th and 31st July 2016.
- The interviews were conducted individually with each person at the same location (at MSS) with the exception of two interviews taking place elsewhere. The tape recordings last from 27 minutes to 44 minutes, with the average duration of 36 minutes.

Data analysis

Interviews were recorded and transcribed verbatim, the result is nearly 100 pages of transcriptions. The data analysis method is qualitative content analysis, with the method of grounded theory (Easterby-Smith et al., 2007; Vogrinc, 2013). Transcriptions were systematically analysed with coding and categorising. A flexible deductive approach was used, in which abstract notions served as a basis; they were checked on empirical data, but in accordance with flexibility new codes and categories were added in the process of analysis (Vogrinc, 2013). Therefore, some categories were formed subsequently (Marvasti, 2004). Open coding, axial coding, and selective coding by Glasser and Strauss were used (Easterby-Smith et al., 2007; Marvasti, 2004). No special software for qualitative analysis was used for data analysis: only Word and Excel.

The study was approved by the Ethics Commission of the Faculty of Education, University of Ljubljana.

Results and discussion

Results

A total of 493 codes were assigned to the data: 352 codes to the teaching methods and 141 codes to the teaching forms. There are 12 categories and 14 subcategories in the data; two categories and four subcategories for the 1st research question on teaching forms (theme: teaching forms) and 10 categories and 10 subcategories for the 2nd research question on teaching methods (theme: teaching methods). The list of teaching methods and forms is not an exhaustive list.

The results indicate the presence of frontal teaching form/direct instruction as well as indirect forms/autonomous work of students in selected NFE in (MSS). The taxonomy of teaching forms is presented in Figure 1.

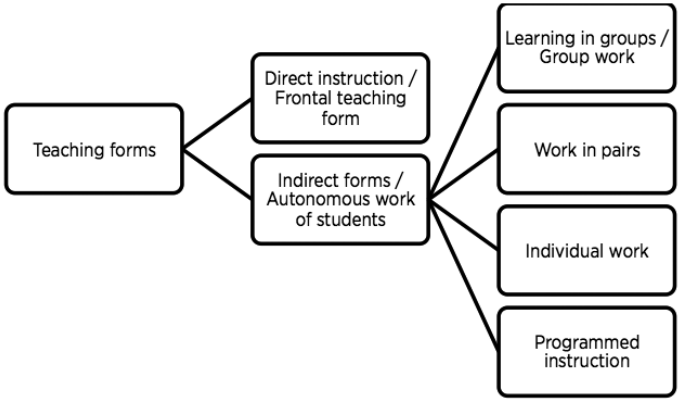

Figure 1. Taxonomy of teaching forms (categories and subcategories) in selected NFE in National Youth Council of Slovenia (MSS).

The results indicate that teaching methods in selected NFE in MSS include the methods presented in Figure 2. The classification of subcategories and further taxonomy is illustrated in Figure 3 (for verbal-textual methods), Figure 4 (for illustrative-demonstration methods) and Figure 5 (for support methods).

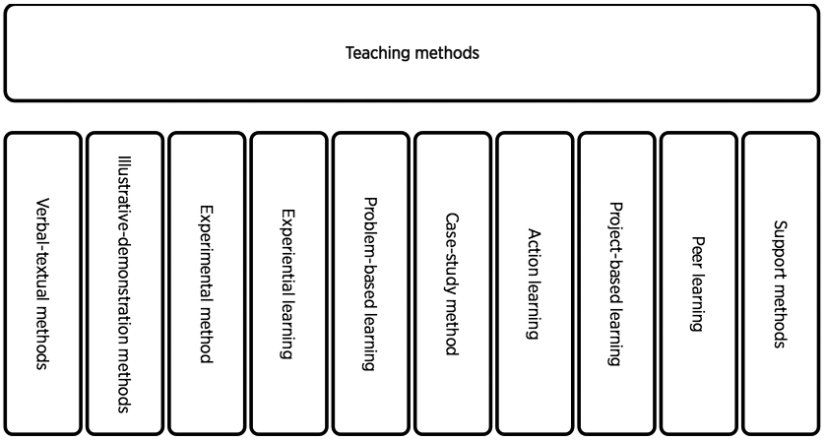

Figure 2. Taxonomy of teaching methods (categories) in selected NFE in MSS.

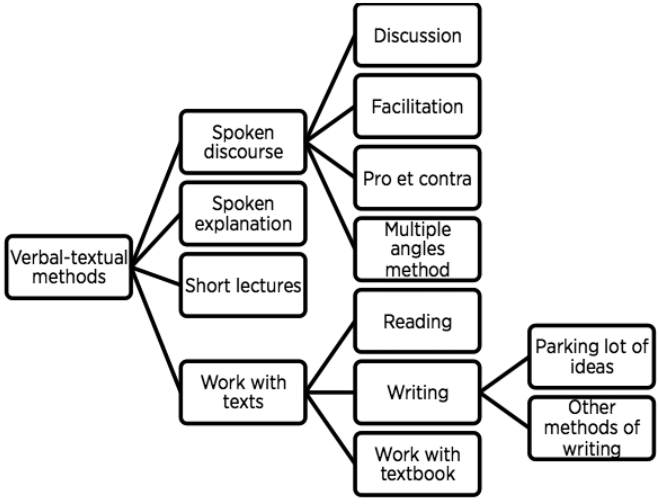

Figure 3. Taxonomy of verbal-textual methods (subcategories) in selected NFE in MSS.

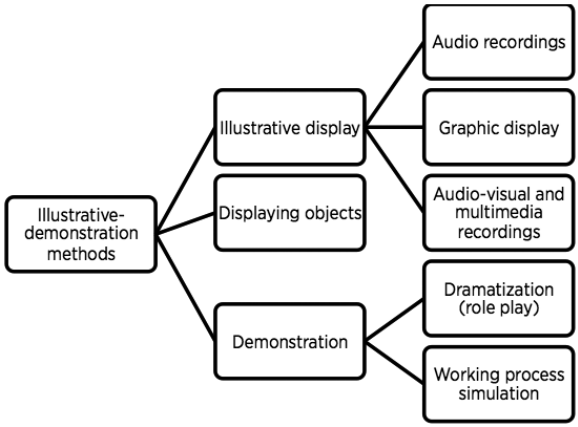

Figure 4. Taxonomy of illustrative-demonstration methods (subcategories) in selected NFE in MSS.

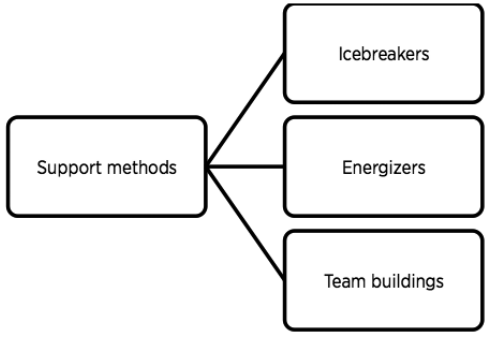

Figure 5. Taxonomy of support methods (subcategories) in selected NFE in MSS.

Teaching forms in selected NFE for youth in youth councils the on national level – in National Youth Council of Slovenia (MSS)

Firstly, it should be noted that the selection of teaching forms and methods in NFE in MSS depends on trainers; according to their internal recommendations, methods and forms for all learning styles should be included. In selected NFE in MSS, the frontal teaching form/direct instruction and indirect forms/autonomous work of students are present. Direct instruction is represented in a small measure. As illustrated by the statement of the interviewee on the participant level (*Ipart*) about the presence of this teaching form: 'Very little, but there was also a bit of that.' Furthermore, the organisers recommend limiting direct instruction; and using it only for covering theoretical aspects.

This is also consistent with theory, since direct instruction is more appropriate for children and younger pupils, who need systematic guidance in comparison with adults with more work- and life experience (Mijoč, 2009). The participants of selected NFE can be defined as older adolescents or young adults, therefore, according to their characteristics, direct instruction is less suitable for them.

Indirect teaching forms are more stressed, and among them learning in groups is the most important, with the biggest part of selected NFE conducted as such. The key teaching form in the selected NFE is learning in groups, corresponds with teaching form present in youth clubs (Eraut, 2004 & Wenger, 1998, in Kiilakoski & Kivijarvi, 2015) and with suitable forms in NFE (Starc et al. 2015). As stated by the interviewee on the trainer level (*Itrain*): 'Well, yes, there was a lot of group work […] it was mostly that'. The groups were of various sizes and consisted of 3 to 24 members. They were structurally different – formed randomly, by instructions or with self-initiative according to the interest. The groups were not permanent; on the contrary, they changed constantly, with participants undertaking different roles in these groups. The interviewees report that group work made them participate more actively; some of them state responsibility towards other group members as the source of motivation. At the same time in this teaching form there is less responsibility on the educator alone to impart knowledge and more on the group and on the individual. Learning in groups encourages communication skills, it makes participants more motivated and consequently more effective, and at the same time raises their responsibility for the results of joint work (Kramar, 2009).

Work in pairs was present in selected NFE in MSS, but to a limited extent. Individual work was present to a limited extent as well. It took place after the completion of a specific content section, in which the participants were expected to write their reflections. Furthermore, it was present when the participants had the task of preparing a presentation on their own. Finally, it can be said that programmed instruction was present if defined as a teaching form with prepared instructions where the individual solves the task without the educator's help. Such a teaching form was present; however, without pre-programmed software, but through a pre-defined learning sheet. As stated by *Itrain*: 'And basically there was no need for an explanation […] there were questions on [the learning sheet] that guided them'. That is contrary to some definitions (Stanković & Blažič, 2015) which associate programmed instruction mainly with computers and refer to it as computer-assisted instruction. Programmed instruction results in increased participation and in individualisation of learning speed (Javornik Krečič et al., 2014).

Teaching methods in selected NFE for youth in youth councils on the national level – in the National Youth Council of Slovenia (MSS)

The results indicate the presence of the following teaching methods in the selected NFE in MSS: verbal-textual methods, illustrative-demonstration methods, experimental method, experiential learning, problem-based learning, case-study method, action learning, project-based learning, peer learning and support methods.

Firstly, verbal-textual methods in our research can be divided into four subcategories (as presented in Figure 3). The interviewees mention spoken explanation, which is used as the additional explanation of content and for interpretation of definitions. The theory is that a well-defined spoken explanation is suitable for theoretical content and for topics that learners would not be able to assimilate to such an extent themselves (Kramar, 2009). Some researchers (e.g., Sapin, 2009) classify passing on information and illuminating as appropriate teaching methods, which is not confirmed by our research, as passing on information and illumination in the sense of spoken explanation and lectures are less represented in the selected NFE. Lectures are less present and appear mostly as short lectures. As illustrated by *Itrain*: 'And there was a small part of theory inside the programme which lasted for 10 minutes.' Lectures are mainly used for giving theory and for unifying knowledge before further work with other methods. Therefore, the research confirms the theory (Kramar, 2009) that they are used for that transmission of content, information and viewpoints that learners shall become acquainted with and adopt. The specialty of the selected NFE is that lectures exist in reversible format, where the participants prepare content and present it to other participants and to trainers in the plenary, therein shifting the roles.

Furthermore, spoken discourse is present in all forms, with participants interacting with one another and through participants' and trainers' interaction, where questions are raised, and feedback is given through active participation. Great importance is attributed to the continuous openness for questions by trainers and the active participation of participants. Trainers often assume the role of facilitators, only facilitating the discourse with participants being a source of knowledge and information. Other methods of spoken discourse, in addition to discussion and facilitation, include 'multiple angles method' and '*pro-et-contra*'. In the verbal methods in the selected NFE, there is a strong focus on dialogue and interaction, and less on monologue.

Finally, work with texts is present throughout the process. It is present as reading (reading of texts; such as definitions appearing on several sheets that need to be assembled into a meaningful whole), writing (writing presentations

of products; recording thoughts, opinions and reflections; writing plans for work tasks) and didactic work with textbooks. In the latter case, the participants receive a book that helps them with their task of preparing their own workshop. As illustrated by the interviewee on an organiser level (*Iorg*): 'All the participants get […] a manual for trainers in youth work […] we provide it'. The writing method includes 'parking lot of ideas', where the participants can write their reflections on a flip chart during the whole day, with discussion following in the evening evaluation. To sum up, work with texts is manifested in reading and in preparation of written material with the constant emphasis on self-activation (Kramar, 2009), as the texts in the selected NFE only represent a basis for participants' activation.

Secondly, illustrative-demonstration methods are also represented in the selected NFE. An illustrative display is manifested through audio recordings, graphic display ('photo-speech method', illustrations, pictures, schematics, etc.) and watching audio-visual and multimedia recordings (films, *YouTube* recordings, etc.). Displaying objects was present through showing different objects and items (balls, flowers, facilitation kit, etc.). As stated by *Itrain*: 'I've learned what Neuland markers are. The co-trainer actually showed the facilitation kit.' Demonstration methods were mostly present through dramatisation and role play, but there was also a working process simulation. An example of dramatisation was described by *Ipart*: 'She had a demonstration about what good public performance looks like and she was actually playing a teacher. And she was playing a teacher who cannot speak well publicly'. The present illustrative-demonstration methods encouraged the perception of participants through the activation of several senses (Tomić, 2000).

Thirdly, the experimental method is also represented in the selected NFE. There was certain bias on the answers to this question; therefore, the results are not entirely valid. There were experiments in a social science context, but there was no laboratory testing of natural phenomena or laboratory work in a natural science context (Tomić, 2000). Such experiments can be illustrated by two examples. Firstly, by simulation exercises in which a certain case was played out three times, each time with different parameters. The second example was the experiment on learning styles, in which participants were divided into three groups with the goal of folding t-shirts using a new technique. One group had audio-recording instructions, the second group had video-recording instructions, and the third group had video-recording instructions together with a t-shirt for testing purposes.

Fourthly, experiential learning was a method that was mentioned by the interviewees most often. It was presented as omnipresent and referred to as

the key teaching method in the selected NFE as well as all NFE in MSS and in youth work in general. *Iorg* stated: 'That is the basic guideline for NFE, at least in the MSS context'. The process of experiential learning follows all four phases of Kolb's circular model, as illustrated by *Iorg*: 'The themes that are learned and presented there are simultaneously tested in practice'. An example mentioned by all interviewees is the part of the selected NFE in which the participants had to independently plan and conduct one workshop after learning the basics of theory. They observed their own and their colleagues' experiences, received and gave feedback at the same time, and implemented it into their own presentation. The research confirms that experiential learning originates in a primary experience and offers active learning, which enables greater internalisation of knowledge, simultaneously increasing its importance and prolonging its memorisation (Timm et al., 2011).

Fifthly, project-based learning can be found in the selected NFE; however more in terms of short projects, covering a limited amount of time, executed within NFE. To exemplify, the participants worked in groups to prepare a plan for a four-day seminar, each covering a certain aspect of the seminar that they had to conduct and perform individually. As illustrated by *Iorg*: '…a kind of project work, where the participants form an activity on their own, they execute it. and the trainer only serves as a mentor in this process'. This is in accordance with the definition of project-based learning in education by Mijoč (2007) as a process in which an individual or a group chooses a problem which they examine, analyse, solve and present the results in front of the group.

Furthermore, the problem method with problem-based learning was present as the participants received specific problems from the practice to solve. They worked in groups to actively resolve complex and real problems (Allen et al., 2011), to which they had to apply all their knowledge and experience. Such learning is perceived as the highest form of learning as it is not only a reproduction of knowledge, but a creative transformation and application of prior-knowledge and experience to new or modified situations (Javornik Krečič et al., 2014). The problem method in the selected NFE can be seen as an independent method or as a part of experiential learning. That also applies to the case-study method in the selected NFE, which is strongly intertwined with experiential learning.

The next teaching method present was action learning. In part of the selected NFE, the participants had to work with peers, perform actions, and reflect upon solutions, which is consistent with Revans' definition of action learning (Brook et al., 2012). Both action learning and the case-study method can be categorised as adult education methods, because they assume the participants

can draw from their own experience, interpersonal relations, and life-situations (Mijoč, 2009). Despite the fact that some participants in the selected NFE might not yet be defined as adults, they fit the categories of younger adults and active citizens (participating in civil society organisations) and, therefore, possess sufficient experience for such methods. Furthermore, problem-based learning, case-study method and action learning are all very intertwined in the selected NFE; therefore, it is difficult to distinguish among them. Primarily, they are all strongly connected with experiential learning, which can be seen as their umbrella method in many aspects. The dilemma of many expressions for similar concepts is also highlighted by other researchers. For example, Mijoč (2007) claims that the project method is often connected with case-study, problem learning, project learning, experiential learning, etc.

Moreover, support methods that were present in the selected NFE can be divided into three sections: icebreakers, energisers, and team buildings. *Iorg* states: 'Almost every workshop has an energiser or an icebreaker for the participants… as we really want them to be present there.' For example, the interviewees mention building with Lego bricks as a team builder and different icebreakers for warming up. Support methods used in the selected NFE aim in helping participants merge into groups, connecting them, and gaining their attention. This is in accordance with Kane (2007), who claims that a good icebreaker can improve the learning environment, encourage socialisation and help participants relax.

Finally, peer learning was also present in the selected NFE. It can be seen as a component of NFE although it is more often present in less structured environments of informal learning (del Felice & Solheim, 2011). However, our research does not explore informal learning; therefore, informal aspects of peer learning are not covered. Peer learning in the selected NFE is present as the transmission of knowledge between the participants and the trainers within other methods (e.g., in discussion); the trainers provide an environment that encourages such learning. As illustrated by *Itrain*: 'There is a lot of learning from each other.' Peer learning can be grouped in the broader concept of participative learning (Sapin, 2009), also referred to as 'participatory learning' (Fennes & Otten, 2008). In the selected NFE participative learning can be found in each teaching method and form. Its presence can be felt through the wording of the interviewees. This can be illustrated by the statements of *Itrain*: 'Altogether, it was very […] inclusive, interactive, reflexive.' and Ipart: 'We had constant interaction with the trainers, we cooperated […]. There were constant calls for feedback'.

Conclusion

Youth in youth organisations learn through seminars, courses (del Felice & Solheim, 2011) and trainings (Souto-Otero, 2016), in the categories of which the selected NFE can be placed. The present research confirms that learning in the selected NFE in the National Youth Council of Slovenia (MSS) is participative, interactive, inclusive and student-focused; with central concepts of experiential learning and learning in groups (Bužinkić et al., 2015; Fennes & Otten, 2008; Sapin, 2009; Sapin & Waters, 1990).

Learning in groups is seen as the primary teaching form in the selected NFE in MSS; however, individual work, work in pairs, programmed instruction, and direct instruction (which is the least represented) are also present. The central and omnipresent teaching method is experiential learning. Problem-based learning, the case-study method, action learning and project-based learning are intertwined and connected to the experiential learning method, which can be seen as their umbrella method. Other methods include verbal-textual methods (spoken discourse, spoken explanation, short lectures, and work with texts), illustrative-demonstration methods (illustrative display, displaying objects and demonstration), experimental methods in social science context, peer learning and support methods (icebreakers, energisers, and team building). Participative learning is typical for youth work, and in the selected NFE it can be found throughout every teaching method and form.

Limitations

The selected NFE took part four months before the interviews; therefore, some errors in recall of the interviewees are possible. Furthermore, the selected NFE was specific, as its aim was to train the participants to conduct the similar NFE on their own. Consequently, they had better knowledge of teaching methods and forms. At the same time, the selected NFE was more methodologically diverse, as the trainers' aim was to present as many methods in forms in practice as possible. Moreover, the list of questions was based on a synthesis of several models and peer-reviewed by one expert only, due to the situational limitations. More peer-reviews might have contributed to a better quality of the instrument. Finally, the author entered the research with certain knowledge of NFE in MSS, and she met with some interviewees before the research.

Applicability of the results and further research

The results of the research are applicative in the didactic spectrum of NFE in youth work and in the wider didactic spectrum of adult learning.

Nevertheless, certain parts of the research can be applied in practice in work with young people inside the formal-education system. Implications for further research include teaching methods and forms in NFE inside the wider youth sector in Slovenia and a comparative analysis of national youth councils in the international context. Furthermore, a quantitative study would be a needed addition to the present research.

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Teaching and Learning Vocabulary: What English Language Learners Perceive to Be Effective and Ineffective Strategies

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Vocabulary constitutes an essential part of every language-learning endeavour and deserves scholarly attention. The objective of the present study was three-fold: 1) exploring Iranian English language learners' Vocabulary Learning Strategies (VLSs), 2) examining language learners' perceptions of vocabulary learning, and 3) exploring Iranian English language teachers' Vocabulary Teaching Strategies (VTSs). In total, 145 intermediate learners of English as a foreign language, consisting of 114 males and 31 females aged 15 to 27, participated in the study. The triangulated data were collected using three tools: questionnaires, interviews, and class observations. Sixty-seven learners (31 females and 36 males) filled out a 56-statement questionnaire, adopted and adapted from Takač (2008) and translated into Persian. The questionnaire comprised two parts, enquiring as to the learners' VLSs and the teachers' VTSs. The findings indicated that females and males differed significantly in their reported VLSs and their teachers' use of various VTSs. Additionally, 78 learners were interviewed as to their perceptions of effective and ineffective VLSs as well as VTSs. The findings revealed that the most effective VLSs were reported to be: a) reciting, repeating and listening to words, b) using words, and c) memorising words while the most effective VTSs revolved around: a) explanation, b) repetition, and c) dictation. The observations also confirmed the findings obtained via the questionnaire and interviews. In general, the findings are indicative of the limited repertoire of vocabulary acquisition techniques employed by Iranian EFL learners, hence the need for strategy training in how to acquire vocabulary.

Keywords: EFL learners, strategies, target language, vocabulary learning, vocabulary teaching

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Poučevanje in učenje besedišča: Katere so uspešne in neuspešne strategije po mnenju učencev angleškega jezika

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Besedišče predstavlja eno ključnih vlog pri učenju tujega jezika, zato si zasluži našo znanstveno pozornost. Sledeča študija si je zastavila tri cilje: 1) preučevanje iranskih učencev angleškega jezika in njihovih strategij za učenje besedišča, 2) raziskovanje, kako učenci tujega jezika dojemajo učenje besedišča, in 3) preučevanje iranskih učiteljev angleškega jezika in njihovih strategij za poučevanje besedišča. V raziskavi je sodelovalo 145 učencev (nadaljevalcev) angleščine kot tujega jezika, od tega je bilo 114 moških in 31 žensk, starih od 15 do 27 let. Triangulacijski podatki so bili zbrani z uporabo treh orodij: vprašalnika, intervjujev in opazovanjem razredov. 67 učencev (31 žensk in 36 moških) je izpolnilo vprašalnik s 56 vprašanji, ki je bil vzet iz Takač (2008) in prilagojen ter nato preveden v perzijščino. Vprašalnik je bil sestavljen iz dveh delov in je povpraševal po strategijah učencev pri učenju besedišča in strategijah učiteljev pri poučevanju besedišča. Rezultati so pokazali, da se ženske in moški občutno razlikujejo glede na odgovore o njihovih strategijah za učenje besedišča in o strategijah za poučevanje besedišča, ki jih uporabljajo njihovi učitelji. 78 učencev je bilo intervjuvanih o njihovem zaznavanju uspešnih in neuspešnih strategij za učenje besedišča ter strategij za poučevanje besedišča. Rezultati so pokazali, da so najbolj uspešne strategije za učenje besedišča naslednje: a) recitiranje, ponavljanje in poslušanje besed, b) uporaba besed, in c) učenje besed na pamet, medtem ko so bile najbolj uspešne strategije za poučevanje besedišča sledeče: a) razlaga, b) ponavljanje, in c) narek. Opazovanja so prav tako potrdila rezultate, ki smo jih pridobili s pomočjo vprašalnika in intervjujev. Na splošno te ugotovitve kažejo na to, da obstaja omejen repertoar tehnik za pridobivanje besedišča, ki jih uporabljajo iranski učenci angleščine kot tujega jezika, zato obstaja potreba po učenju strategij, kako pridobivati besedišče.

Ključne besede: učenci angleščine kot tujega jezika, strategije, ciljni jezik, učenje besedišča, poučevanje besedišča

Introduction

It goes without saying that vocabulary plays a pivotal role in every endeavour to learn a new language. The importance of the lexicon has been recognised in almost every language-teaching method from the traditional Silent Way in which the most versatile and functional vocabulary was emphasised (Richards & Rodgers, 1999) to the more recent Communicate Language Teaching in which teachers utilise a wide variety of techniques such as definition, synonyms and antonyms, to teach vocabulary (Savignon, 2002).

Vocabulary is believed to be the cornerstone of language courses (Torki, 2011). Vocabulary acquisition also remains a very active area of research with significant implications to inform practice (Adolphs & Schmitt, 2004), and it is assumed that growth in vocabulary takes place as a result of gains in language proficiency (Milton & Alexiou, 2009). Therefore, research on vocabulary teaching has also assumed central importance in language teaching research (Milton & Alexiou, 2012). Over a decade ago, Read (2000, p. 1) cautioned that 'even at an advanced level, learners are aware of limitations in their knowledge of second language (or L2) words'. Researching vocabulary learning (VL) is of valuable help to pedagogy (Laufer, 1998) as 'vocabulary is now a current focus in ESL pedagogy and research' (Wei, 2007, p. 94).

Furthermore, successful vocabulary acquisition has been associated with successful reading ability (Dickinson, Flushman, & Freiberg, 2009), with becoming more communicative, able, and skilled (Milton & Alexiou, 2009), among others. Conversely, failure in learning vocabulary is believed to lead to difficulties in language reception and production (Wei, 2007) as well as to 'a sense of insecurity' and 'breakdown in communication' (Hurtado, 2002). Saunders (2013) contends that it is important to determine the VLSs favoured by students prior to embarking on research that aims at determining the best strategy to learn vocabulary. Accordingly, the present study is an attempt to delve into the perceptions of Iranian EFL learners concerning the role and importance of vocabulary, and the strategies utilised to learn and teach it.

Review of Literature

Although the scholarly literature on vocabulary learning (henceforth VL) and vocabulary teaching (henceforth VT) is vast nowadays, vocabulary was not given the recognition and acknowledgment it fully deserved due to the overwhelming emphasis laid on syntax for decades (Hurtado, 2002). However, this line of research remains an active area of debate and discussion so that,

in addition to research articles, full volumes have been dedicated to the issue of vocabulary as well (e.g., Bogaards & Laufer, 2004; Gewehr, 2002; Richards, Daller, Malvern, Meara, Milton, & Treffers-Daller, 2009).

A respectable stockpile of research has concentrated on distinct and diverse issues with regard to VL and VT. In this regard, Nilsen (1976) analysed the concept of 'context' in providing words with meaning by means of contrastive semantics. Richards (1976) focused on the various aspects of vocabulary as the building blocks of lexical competence. In contrast, Lawson and Hogben (1996) examined VLSs of students of Italian as a foreign language by use of think-aloud protocols with the result that the students were found to rely heavily on repetition as a major VLS. Laufer (1998) examined gains in three types of English vocabulary, passive, controlled active and free active. More recently, Suberviola and Méndez (2002) discussed the necessity, methods and activities of vocabulary acquisition, emphasising the importance of semantic maps in enhancing students' ability to recall words. Sex differences in VLS use were examined by Catalán (2003) who determined that while many of the strategies were common among males and females, females used higher percentages of vocabulary strategies. Qian (2004) investigated lexical inferencing strategies among Korean and Chinese students of English to find that a top-down approach, specifically guessing from context, was the major strategy used. In an experimental study, Zhiliang (2008) examined the effect of three learning strategies on Chinese EFL learners' incidental vocabulary learning. The study produced evidence for the superiority of the combined method of guessing and an e-dictionary over guessing from context using an e-dictionary.

Various researchers have stressed distinct issues concerning lexis. Hurtado (2002), for instance, conducted a study on how to teach vocabulary, suggesting that 'lexical hierarchies' are a suitable way of presenting words systematically since 'One of the paradoxes in VT in the FL classroom is that despite the amount of time devoted to explaining and defining words, vocabulary is rarely presented to students in a systematic way' (p. 176). While Li (2004) and Sinhaneti and Kyaw (2012) focused on rote learning in vocabulary acquisition and its efficacy, the size of the vocabulary needed for unassisted comprehension of spoken and written language was the central point of Nation (2006). Brown's (2013) study demonstrated that content and language-integrated learning (CLIL) has positive effects on VL among medical students. Similarly, in an online survey, Saunders (2013) showed that memorisation of the translations of words and writing them were the most popular methods Japanese EFL learners used to learn vocabulary. In another study, Akpınar and Bardakçı (2015) examined and highlighted the positive impact of grouping and collocation on vocabulary retention.

Further research can yield a more profound understanding of the nature of vocabulary acquisition among language learners. As for the Iranian context, examining the effect of the type of task with a focus on the type of dictionaries on lexical learning among Iranian EFL university students, Maghsodi (2010) demonstrated that monolingual dictionaries were more effective in lexical retention. Ahour and Esfanjani (2015) determined that cognitive strategies were the most frequent strategies used in learning vocabulary among poor Iranian EFL learners. Considering the lack of rigorous research on VL and VT in an EFL context like Iran, the present study set out to examine these two issues further so as to provide more illuminating insights in this connection.

Research Questions

The present study aimed at exploring the beliefs of Iranian EFL learners about FL vocabulary acquisition and instruction. Specifically, the study set out to provide answers to the following research questions:

RQ 1. What are the most common VLSs of Iranian EFL learners?
RQ 2. Do Iranian male and female EFL learners differ significantly in their VLS use?
RQ 3. What are the most common VTSs of Iranian EFL teachers as reported by the learners?
RQ 4. Is there any significant difference in male and female learners' reports of teachers' VTS use of Iranian EFL teachers?

Method

Participants

The overall number of the participants was 145 intermediate learners of English as a foreign language (EFL) including 114 males and 31 females. In general, three data collection tools were used in the current study: questionnaires, interviews and class observations. Two groups of participants took part in the study: the questionnaire respondents (67 participants) and interviewees (78 participants). Since it was too time-consuming and cumbersome to administer both data collection instruments to all the participants, the questionnaire was administered to 67 participants while the remaining 78 other participants were interviewed only. Therefore, both quantitative and qualitative data were generated. By doing so, which was because of practicality issues, more reliable data were produced. Further details on the participants are provided below.

The questionnaire respondents consisted of 67 students of English (31 females and 36 males). They were within the age range of 15–27 (mean =18.5) and came from Ahvaz, Iran. As regards their ethnic and linguistic backgrounds, the participants consisted of 63 Persians (94%) and four Arabs (6%). Furthermore, regarding their educational background, the participants included 48 high school students (72%) and 19 university students/graduates (28%). All the participants were at the intermediate level of their English language learning. Additionally, regarding the duration for which the participants' teachers had been teaching the participants when the study was conducted, the participants reported that their teachers had taught them for almost one year in 92.5% of the cases, two years in 6%, and three years in 1.5% of the cases. The participants were also asked to report their last score in English out of 100. The results for this part showed that the scores varied from 60 to 98, with 15% of the scores falling within 60–84 and the remaining 85% falling within the range of 85–98. Finally, the demographic information elicited indicated that while 57% of the participants had started learning English before their teenage years, 43% had started it after their first teenage year (i.e., after age 13). (To see the questionnaire, see Tables 1 & 3).

Instruments

Triangulation is believed to enhance the reliability and validity of research and is divided into three types: theoretical, investigatory, and methodological triangulation (Mackey & Gass, 2005). As Ary, Jacobs and Sorensen (2010) pointed out, 'Triangulation seeks to examine the convergence of evidence from different methods that study the same phenomenon or to corroborate findings from one method by examining the findings using a different method' (p. 561). The current study benefited from methodological triangulation by using different data collection instruments, and the required data were gathered by means of three data collection tools, as outlined below.

Vocabulary Learning and Teaching Strategies Questionnaire

In the first place, the data required for this study were collected by means of a questionnaire, adopted and adapted from Takač (2008), which consisted of two parts which comprised 56 statements. The participants were required to select each statement on a three-point Likert scale (i.e., 1: Never, 2: Sometimes, and 3: Always). Part 1 included 27 statements enquiring as to the learners' VLSs while Part 2 comprised 29 statements enquiring about the teachers' VTSs. The original questionnaire was in English but for the better comprehensibility it was translated into Persian, the participants' mother tongue. The translation

was checked out by two more researchers who spoke Persian as their native language and who were also fluent in English. Based on the researchers' comments, the questionnaire underwent some slight modifications.

Semi-structured Interviews

Flexibility has been mentioned as one of the most important features of interviews (Ary et al., 2010). In line with this feature, the participants were interviewed so that a deeper understanding of their perceptions of VLSs and VTSs could be gained. The interviewees consisted of 78 male EFL learners with characteristics similar to the questionnaire respondents'. The interviews revolved around such aspects of vocabulary knowledge as the students' views of the most and least effective VLSs and VTSs, the interviewees' own VLSs and the students' and teachers' role in vocabulary acquisition. The interview data are reported separately in the Results section, and the interview questions appear in Appendix A.

Classroom Observation

As Mackey and Gass (2005) noted, observations, commonly used in classroom research for gathering data on such phenomena as language, activities and instruction, 'can allow the study of a behaviour at close range with many important contextual variables present' (p. 187). This final phase of data collection included class observations which were done following the purpose-built Observation Checklist (Appendix B) in six randomly selected private language institute classes on a period of six months (composing three consecutive institute semesters). In total, 10 class observations were done.

The data collection procedure included a phase in which the questionnaire was piloted with a number of 20 students with features similar to those of the main and final sample of the study. As predicted, the answers provided by the participants in the pilot study suggested that some of the statements of the questionnaire needed further clarification, modification, and rewording. For example, the Persian translation of Statement 15 (Part 2) was further clarified as the participants pointed out that they found it ambiguous. Furthermore, the original 'spaced word practice' (Statement 24, Part 1) was replaced with the more familiar (and more 'popular') 'Leitner box' exercise. As a result, the number of the questionnaire statements was not changed but the content was modified to assure the participants' full comprehension.

Data Analysis

The data were collected in the order in which the instruments were introduced above. That is to say, first, the questionnaire was administered to the participants. Next, the participants were interviewed and, finally, the class observations were conducted. The quantitative data were analysed using the Statistical Package for Social Sciences (SPSS) software by means of descriptive statistics and independent samples *t*-tests, which were utilised to compare the results of gender differences in perceptions. Additionally, qualitative interview data were analysed by extracting, classifying, and categorising the strategies and themes mentioned by the participants. Finally, the data gathered through class observations were engendered by use of an observation checklist.

Results

The findings are presented in this section which, for readability purposes, has been divided into two main parts, namely 'vocabulary learning strategies' and 'vocabulary teaching strategies'. The questionnaire results and the interview results are then provided for each section. It is noteworthy that most interviewees named more than one VTS and VLS, hence the discrepancy between the number of the interviewees and that of the VLSs and VTSs. The boldfaced percentages in Tables 1 and 3 indicate the highest percentages for each statement for both males and females.

Vocabulary Learning Strategies (VLSs)

As mentioned earlier, the questionnaire was intended to provide insights into, primarily, the participants' VLSs and, secondarily, their reports of teachers' VTSs. Table 1 presents the participants' VLS use. It also presents the percentages with which female and male participants selected each VL strategy. Therefore, this part is an attempt to answer the first research question.

Table 1
VLS Results across Gender (N=67)

No.	Statement	Female			Male		
		1-Never	2-Sometimes	3-Always	1-Never	2-Sometimes	3-Always
1	I use new words in a sentence in order to remember them.	6.5	**67.7**	25.8	13.9	**66.7**	19.4
2	I make word lists and write their translations in my mother tongue.	12.9	38.7	**48.4**	36.1	22.2	**41.7**
3	I review words regularly outside the classroom.	3.2	**71**	25.8	13.9	**52.8**	33.3
4	I test myself to check if I remember the words.	3.2	**48.4**	**48.4**	8.3	41.7	**50**
5	I pick up words from films and TV programmes I watch.	6.5	**51.6**	41.9	11.1	30.6	**58.3**
6	If I cannot remember a word in a conversation, I use another one with a similar meaning.	3.2	**54.8**	41.9	2.8	50	47.2
7	I write down words while I read books and magazines for pleasure.	51.6	**48.4**	0	38.9	**44.4**	7
8	I plan for vocabulary learning in advance.	35.5	**48.4**	16.1	**44.4**	33.3	8
9	I remember a word if I see it written down.	0	45.2	**54.8**	0	**47.2**	9
10	I say a word out loud repeatedly in order to remember it.	9.7	19.4	**71**	27.8	**41.7**	30
11	I connect an image with a word's meaning in order to remember it.	16.1	**61.3**	22.6	25	**50**	11
12	I associate new words with the ones I already know.	9.7	**67.7**	22.6	30.6	**41.7**	12
13	I write down words when I watch films and TV programmes.	41.9	**51.6**	6.5	**47.2**	38.9	13
14	I write down words repeatedly to remember them.	22.6	**64.5**	12.9	**44.4**	**44.4**	14
15	I read and leaf through a dictionary to learn some new words.	**48.4**	41.9	9.7	41.7	**47.2**	15
16	I make a mental image a word's written form in order to remember it.	25.8	**48.4**	25.8	44.4	36.1	16
17	If I cannot remember a word in a conversation, I describe it in my own words in the foreign language.	3.2	**64.5**	32.3	16.7	**55.6**	27.8
18	I imagine a context in which a word could be used in order to remember it.	12.9	**71**	16.1	27.8	**52.8**	19.4

No.	Statement	Female			Male		
		1-Never	2-Some-times	3-Always	1-Never	2-Some-times	3-Always
19	I translate the words into my mother tongue to understand them.	3.2	16.1	**80.6**	8.3	19.4	**72.2**
20	I group words together in order to remember them.	**45.2**	38.7	16.1	36.1	**52.8**	11.1
21	I repeat the word mentally in order to remember it.	3.2	29	**67.7**	5.6	38.9	**55.6**
22	I listen to songs in the foreign language and try to understand the words.	9.7	38.7	**51.6**	22.2	33.3	**44.4**
23	I pick up words while reading books and magazines in the foreign language.	9.7	**58.1**	32.3	5.6	**47.2**	**47.2**
24	I use Leitner's box in order to remember words.	**77.4**	19.4	3.2	**69.4**	25	5.6
25	I connect words to physical objects to remember them.	38.7	**51.6**	9.7	**55.6**	36.1	8.3
26	I test myself with word lists to check if I remember the words.	9.7	29	**61.3**	8.3	**44.4**	**47.2**
27	I pick up words from the Internet.	29	**58.1**	12.9	19.4	33.3	**47.2**

As can be seen from Table 1, the three most frequent strategies include: a) Statement 1: using words in sentences (67.2%), b) Statement 19: translation of words into mother tongue (76.1%) and c) Statement 21: mental repetition of words (61.2%). In contrast, this table also shows that the least frequent strategies are: a) Statement 13: writing down words from films and TV programs (44.8%; Never), b) Statement 15: using dictionaries (44.8%; Never) and c) Statement 24: using Leitner's box (73.1%; Never).

Table 2 displays the results of an independent samples test which was run to examine if males and females differ significantly in their VLS use, an issue that was addressed in the second question.

Table 2
Independent Samples Test of VLSs

Questionnaire item	t-test for Equality of Means			
	t	df	Sig. (2-tailed)	Mean Difference
Item 10	-3.286	65	.002	-.585
Item 27	2.499	65	.01	.439

Note. $t_{\text{Item 10}}(65) = -3.286$; $p < .05$. $t_{\text{Item 27}}(65) = .68$; $p < .05$.

According to Table 2, males and females differ significantly in statements 10 and 27. By referring to Table 1 above, one can understand that while females are more willing than males to 'say out a word out loud to memorise it' (statement 10), males are more inclined than females toward 'picking up words from the Internet'.

As Table 1 indicates, using words in sentences is among the most frequent VLSs. The next common strategy was found to be translating target language (TL) words into the mother tongue. This finding concurs with results obtained by studies carried out in other cultures, for example, Chinese (Li, 2004) and Burmese (Sinhaneti & Kyaw, 2012). This strategy is believed to be ineffective and to lead to unsuccessful vocabulary learning (Suberviola & Méndez, 2002). Finally, the third most favoured strategy was the mental repetition of words. Another finding is the low interest of the learners in using dictionaries and Leitner's boxes, two strategies that have been documented to be effective and essential tools for developing one's lexical abilities and vocabulary retention (e.g., Bruton, 2007; Linares, 2002).

The low appeal of dictionaries to Iranian EFL learners is surprising and can be attributed, tentatively, to their lack of what Linares (2002) terms 'dictionary awareness', asserting that, 'a person with dictionary awareness is one who knows where to find the information he needs and how to extract it' (p. 163). Linares further states that dictionaries can serve the purposes of vocabulary learning independent of the teacher. Therefore, it can be assumed that dictionaries can be used to foster learner autonomy to some extent. However, students should be made aware of the superiority of monolingual dictionaries over bilingual dictionaries as pointed out in the literature (e.g., Maghsodi, 2010).

The learners saw it as the teacher's responsibility to expose them to a considerable amount of contextualised vocabulary. Meara (2002) proposed that exposing learners to large texts 'provides enough examples for the meanings of a core vocabulary to be identified with a fair degree of reliability' (p. 405). Overall, the results of the interviews and the questionnaire clearly demonstrated that the participants had three main concerns regarding the lexicon: spelling, pronunciation and use. This conclusion is particularly grounded upon the participants' responses in the interviews in which they declared they would write a word to learn it, repeat it after the teacher or the CD to learn its pronunciation, and ask their teachers for clarifying examples or look up a word in a dictionary to see how and in what context it is utilised.

This section reports the findings obtained by means of the interviews, which were carried out with 78 participants. The interview transcripts were analysed closely, and the VLSs named by the learners were extracted and presented in Figures 1.

Figure 1 displays the VLSs that the interviewees reported to be effective in learning English vocabulary.

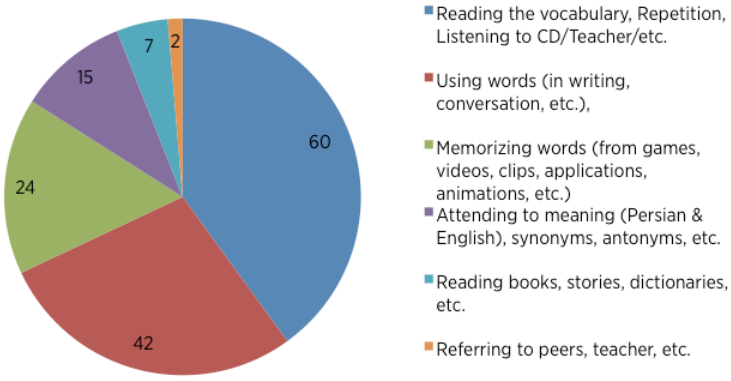

Figure 1. Effective VLSs (Interview results).

According to Figure 1, reading and repeating constitutes the learners' most favoured strategy to learn vocabulary followed by using words in a specific context. The participants also stated that every strategy that is not in accordance with the abovementioned 'effective' VLSs is ineffective and should not be used by learners.

The participants' responses, both in the interviews and to the questionnaire, show that they perceive the role of the L1, if judiciously used in and out of class, as facilitating the VL process. The idea of the use of the students' L1 has been hotly debated in the literature with L1 viewed as both a help (Auerbach, 1993; Brooks-Lewis, 2009; Jafari & Shokrpour, 2013; Khresheh, 2012; Mart, 2013) and a hindrance (Brooks-Lewis, 2009; Mart, 2013). Additionally, while the participants mentioned that they were interested in the use of more innovative ways of learning vocabulary such as through videos, clips, applications, imagery, laptops, computers, and so on, their information concerning how this should be carried out was limited. This amounts to saying that students are in need of considerable cognizance in how to utilise new VL techniques on their own.

Vocabulary Teaching Strategies (VTSs)

This part presents the results of the students' reports of the VTSs practiced by the teachers; therefore, it is an attempt to answer the third research question.

Table 3 presents the results of VTS use as selected by females and males with the purpose of highlighting the differences across gender groups.

Table 3
VTS Results across Gender (N=67)

No.	Statement	Female			Male		
		1-Never	2-Sometimes	3-Always	1-Never	2-Sometimes	3-Always
1	The teacher helps us to remember words by giving us the initial letter of the word.	19.4	**74.2**	6.5	30.6	**50**	19.4
2	The teacher tells us to group words.	**61.3**	29	9.7	**61.1**	30.6	8.3
3	The teacher gives us (oral and written) tests to check our vocabulary knowledge.	16.1	**48.4**	35.5	38.9	19.4	41.7
4	The teacher tells us to mentally repeat words in order to remember them.	12.9	41.9	**45.2**	11.1	33.3	**55.6**
5	The teacher gives us instructions and advice on how to study words at home.	3.2	**71**	25.8	19.4	**52.8**	27.8
6	The teacher gives several example sentences in which new words are used.	3.2	29	**67.7**	5.6	36.1	**58.3**
7	In tests, the teacher gives us a word and we have to use it in a sentence.	35.5	**41.9**	22.6	**63.9**	19.4	16.7
8	The teacher writes new words on the board.	25.8	**48.4**	25.8	16.7	13.9	**69.4**
9	The teacher asks us to review words regularly at home.	0	**51.6**	48.4	5.6	16.7	**77.8**
10	The teacher uses real objects when explaining the meaning of new words.	38.7	**48.4**	12.9	36.1	**44.4**	19.4
11	The teacher tells us to make a mental picture of the new word's meaning in order to remember it.	38.7	**58.1**	3.2	38.9	**50**	11.1
12	When testing, the teacher shows a picture and we have to supply the word in the foreign language.	**67.7**	22.6	9.7	**63.9**	33.3	2.8
13	The teacher tells us to write down the word several times to remember it.	45.2	**48.4**	6.5	**66.7**	27.8	5.6

No.	Statement	Female			Male		
		1-Never	2-Sometimes	3-Always	1-Never	2-Sometimes	3-Always
14	The teacher asks for translation into the mother tongue.	**64.5**	29	6.5	**69.4**	27.8	2.8
15	The teacher draws the word's meaning on the board.	45.2	51.6	3.2	**52.8**	30.6	16.7
16	When testing, the teacher gives us a word in the mother tongue and we have to translate it into the foreign language.	**80.6**	16.1	3.2	**86.1**	11.1	2.8
17	The teacher explains the new word's meaning in the foreign language.	0	19.4	**80.6**	0	19.4	**80.6**
18	The teacher asks us to look up the new word in the dictionary.	0	**61.3**	38.7	11.1	44.4	44.4
19	The teacher tells us to use the new word in a sentence.	9.7	12.9	77.4	5.6	47.2	47.2
20	The teacher advises us to write down words we hear in films and TV programmes in the foreign language.	**48.4**	45.2	6.5	**44.4**	36.1	19.4
21	When we cannot remember a word, the teacher reminds us of where it appears in the textbook.	**54.8**	35.5	9.7	**63.9**	25	11.1
22	The teacher advises us to write down words when we read books and magazines for pleasure in the foreign language.	**48.4**	41.9	9.7	30.6	**50**	19.4
23	The teacher points to the similarities in sound and meaning between mother tongue and foreign language words (cognates).	22.6	**64.5**	12.9	25	**44.4**	30.6
24	The teacher connects new words with the ones we have learnt previously.	6.5	**67.7**	25.8	8.3	**50**	41.7
25	The teacher tells us to imagine a situation in which the new word would be used in order to remember it.	32.3	**54.8**	12.9	16.7	**58.3**	25
26	The teacher describes a situation in which the new word could be used.	12.9	**64.5**	22.6	16.7	22.2	**61.1**
27	The teacher tells us to underline new words in the text.	35.5	**51.6**	12.9	36.1	25	**38.9**
28	The words we learn are repeatedly mentioned in foreign language classes.	6.5	**51.6**	41.9	5.6	38.9	**55.6**
29	When testing, the teacher gives the foreign language word and we have to translate it into our mother tongue.	**80.6**	16.1	3.2	**91.7**	8.3	0

As shown in Table 3, the participants reported that, most frequently of all, teachers sought recourse in: a) Statement 6: providing example sentences

(62.7%), b) Statement 9: asking students to review words at home (64.2%), c) Statement 17: explaining words in the FL (80.6%).

Additionally, the three least frequent VTSs were: a) Statement 14: translating FL words into mother tongue (67.2%; Never), b) Statement 16: translation of words from mother tongue into FL (83.6%%; Never) and c) Statement 29: translation of words from FL into mother tongue (86.6%; Never). As can be seen, other less common VTSs also include: Statement 2: Grouping words (61.2%; Never), Statement 12: showing pictures to assess vocabulary acquisition (65.7%; Never) and Statement 21: Reminding students of where a word appears in a book (59.7%; Never).

As with the VLSs, an independent samples test was run to check if there was any significant difference between males and females in their views of VTSs (Table 4 below). This part addresses the fourth research question.

Table 4
Independent Samples Test of VTSs (Part 2)

Questionnaire item	t-test for Equality of Means			
	t	df	Sig. (2-tailed)	Mean Difference
Item 8	2.856	65	.006	.528
Item 26	2.035	65	.046	.348

Note. $t_{Item\ 8}(65) = 2.856$; $p < .05$. $t_{Item\ 26}(65) = 2.035$; $p < .05$

As Table 4 shows, according to the participants' reports, teachers made more use of the boards (statement 8) and described a situation for the use of the new word (statement 26) more often with males than with females.

This part presents the results of the interviews concerning the most effective VTSs. Figure 2 displays the VTSs that the interviewees considered effective and helpful.

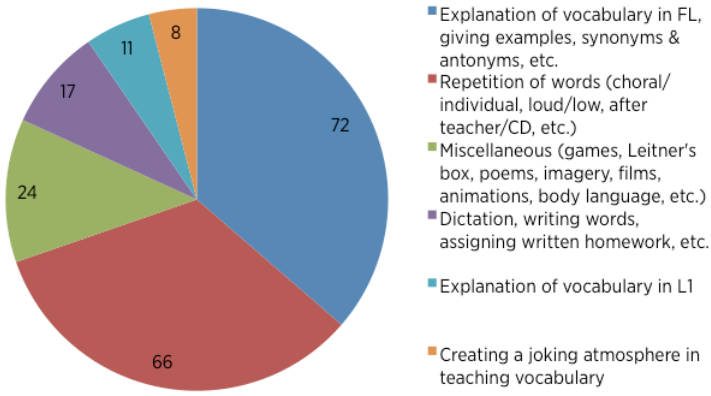

Figure 2. Effective VTSs (Interview results).

According to Figure 2, the participants regarded explanation in the TL accompanied by the provision of examples and repetition as the first two most effective strategies. Explanation in L1 was, however, the least favoured VTS. Notably, while the former strategy was found to be congruent with some previous research, the latter did not support it (see, e.g., Alexiou, 2001).

Figure 3 displays those strategies that the interviewees considered to be ineffective and unhelpful for teaching vocabulary.

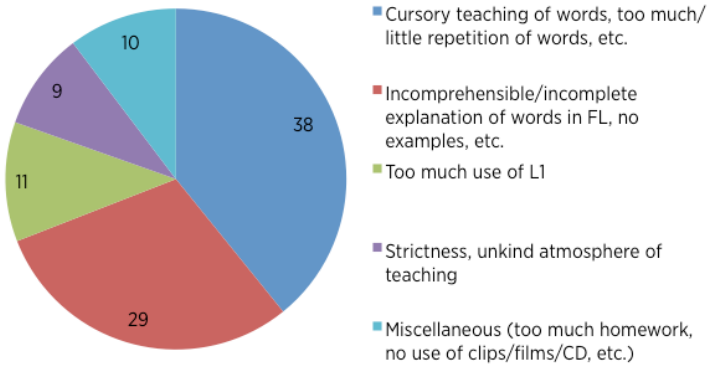

Figure 3. Ineffective VTSs (Interview results).

It can be seen from Figure 3 that superficial attention to words is regarded as the major cause of the unsuccessful instruction of foreign language words. This is followed by inadequate or complicated and, as a result, inexplicable explanation of words, particularly in the TL. The third factor was stated

to be the unreasonably excessive use of L1. Finally, the atmosphere of the classroom setting along with a number of 'miscellaneous' causes were mentioned as other influential factors.

As reported in Table 3, the questionnaire respondents reported that their teachers utilised three major strategies: providing explanations in the FL, example sentences as well as asking students to review words out of the class setting. It is very comforting to see that Iranian EFL teachers use these strategies, and it is expected that such strategies will result in the learners' improved retention of words. Interestingly, although using context to teach vocabulary is enthusiastically recommended by researchers, Lawson and Hogben (1996) suggested that a distinction should be made between contextualising a word for the *generation* of meaning and contextualising it for the *acquisition* of meaning. They emphasised that these two functions of contextualisation are not of the same value and reported, somewhat warningly, that although students were able to generate meaning for words, they were not able to recall them for subsequent use. Lawson and Hogben attributed this inability to teachers' focus on contextualisation for meaning generation instead of their focusing on the acquisitional contextualisation. Other researchers have stressed the significance of training learners in the use of context as an effective strategy in comprehending texts replete with unfamiliar vocabulary (e.g., Walters, 2006) as well as to enhance students' collocational ability with the purpose of subsequent lexical improvement (e.g., Akpınar & Bardakçı, 2015).

The findings of the current study do not lend full support to some previous studies. For instance, unlike Takač's (2008) findings, the results of the present study confirm that the participants' VLS use is congruent with and parallel to their teachers' VTS use. To set an example, learners used words in sentences to learn them and teachers provided the students with example sentences to teach words. Ježek (2016) defined context as 'the set of words that immediately precede or follow it, that is, its immediate linguistic environment' (p. 55), dividing it into three different kinds of syntactic, semantic, and situational (or pragmatic or extra-linguistic) context. Implied in this division of contexts is the fact that teachers are to be made aware that they can rely on these different types of contexts to teach vocabulary. Emphasis on context from which the meaning of unknown words can be guessed is considerable (see, e.g., Qian, 2004).

In contrast, the results confirm Takač's (2008) findings in that the participants were found to use VLSs that were not necessarily utilised by teachers. For example, while the majority of the students translated words from the FL into their mother tongue, teachers were reported to use this strategy the least frequently of all (see Tables 1 and 3). To set another example, while teachers were

reported to emphasise dictionary use, nearly half of the participants asserted that they never used dictionaries to learn vocabulary. This finding warrants attention since the importance of the use of dictionaries in learning vocabulary has been regularly acknowledged in the literature (Linares, 2002).

The last question of the questionnaire enquired as to the amount of importance of both the teachers' and learners' role in vocabulary acquisition, requiring the participants to assign a percentage to the teacher and learner. Figure 4 presents the results of the calculation of the mean of percentages assigned to such roles.

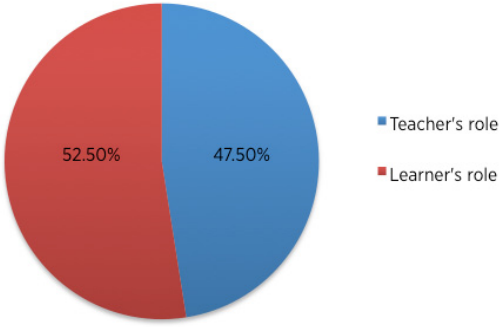

Figure 4. Importance of Teacher's and Learner's Role in Vocabulary Acquisition.

According to Figure 4 and the percentages reported for the roles of the teacher and learner, the participants viewed both roles as almost equally important.

A word on Gender

Regarding the role of gender, the results indicated that the two gender groups differed significantly in both their VLSs and VTSs although the differences were limited to only four statements of the questionnaire. Gender-induced differences have already been documented in the literature. Catalán (2003), for instance, found differences in the number and type of strategies that males and females used to learn vocabulary and attributed these differences to the possible discrepancies in the perceptions of the two genders. The results of our study can be taken as further evidence to support Catalán's (2003) tentative statement, thus suggesting that teachers might wish to utilise different strategies to teach vocabulary in male-only or female-only classes.

This conclusion well applies to the Iranian context owing to the policy of single-sex education followed nation-wide. On the face of it, our results might imply that teachers should utilise different strategies to teach vocabulary to the two genders. As Takač (2008) also obtained similar results, the significant differences found between the two genders' VLSs and VTSs were both very low in number, and the mean score differences were not very high. It may, therefore, be more reasonable to ignore the possible theoretical significance of these differences and instead focus on the VLSs and VTSs as the findings of major interest.

Emerging Categories

By casting a closer glance at the results of the interviews, as shown in Figures 1, 2, 3 and 4, it can be concluded that almost all of these VLSs and VTSs, both effective and ineffective, can be grouped under three unifying, interrelated, and perhaps inter-dependent, sets as shown schematically below:

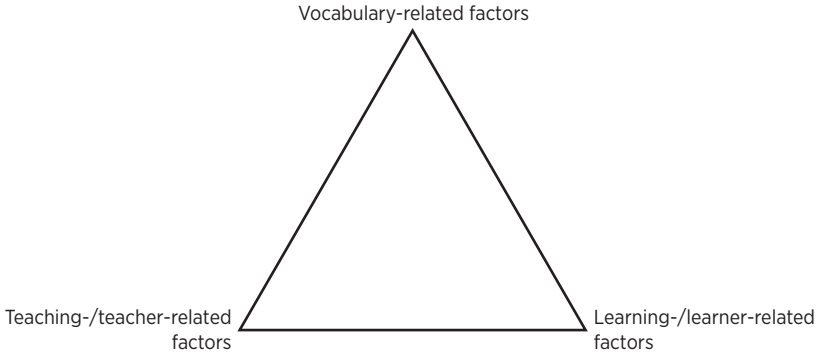

Figure 5. Three sets of factors influencing VL.

In a sense, Figure 5 can be said to provide a synopsis of all the findings of the present study in that it comprises issues concerning the vocabulary itself (e.g., synonymy, polysemy, pronunciation, etc.), issues regarding the context of teaching vocabulary (e.g., creating a playful and funny setting, providing good, comprehensible explanations, etc.) and finally factors relating to the learning and learner including repetition, constant, steady practice, and so on. The findings demonstrate that the participants have deemed all these factors to be intertwined, one set of factors influencing the other, one complementing the other but each somehow independent of the other.

Observational Results

The data engendered through class observations were congruent with the questionnaire and interview data. Specifically, teachers were observed to rely on explanations, giving example sentences and synonyms and antonyms more than any other VT techniques. Games, realia and objects were rarely used and were mostly limited to classes with young learners or beginners. Most of the objects included those already present in class such as whiteboard, desks, tables and neighbouring objects such as apartments, streets, and shops. Rarely, if ever, did teachers bring any objects to class except for personal things, such as car keys, sunglasses, and pens.

It was also observed that students were more attentive when the class atmosphere turned more playful. This playfulness was at times due to cultural reasons, too. For instance, in clarifying the use of 'Miss', a male teacher stated that 'Miss' is used as an attention-seeking address term when a woman is addressed, giving the example: '*May I have your phone number, Miss?*'. Interestingly enough, occasional situations such as these produced a high level of attention among learners. This congenial atmosphere, notwithstanding, was only sporadic and it seems that teachers did not favour it for such reasons as it becoming tiresome, fatigue, burnout, discipline issues and so forth.

Generally, as was predicted from the questionnaire and interview results, the class observations lent much credence to the questionnaire and interview findings but the difference was that in the case of observations, more tangible, practical findings were obtained. Teachers read the word list and the students repeated after them. This technique, which on the surface of it seemed monotonous and boring to adults, was mainly favoured by young learners. Repetition was either choral or individual followed by teachers' explanations, examples and asking students to present their own examples. This technique was used in nearly all classes observed though not to the same extent. The observations therefore confirm the findings obtained from the questionnaire and interviews.

Conclusion

The main thrust of this research study was to capture a triangulated picture of VLSs among Iranian EFL learners along with a depiction of teachers' VTSs. Implied in the discussion above is the fact that Iranian EFL learners use a good variety of VLSs. Despite this finding, the participants asserted that their teachers' vocabulary instruction revolved around certain types of VTSs. The claim here is not that teachers' VTSs are ineffective but that teaching vocabulary

may require the use of a larger number of strategies. The limited number of VTSs practiced by teachers might be attributable to the fact that teachers themselves are not trained in employing strategies wider in variety and number. If this statement turns out to be true, then it follows that VT training workshops and courses, by way of example, are to be set up where teachers are trained as to how to enhance students' lexical repertoire and their VL techniques.

Provided that there is a consensus among researchers on this issue, then research attention will understandably shift to teachers who are expected to shoulder the burden of strategy teaching in VL. The use of tasks in teaching vocabulary has also been strongly recommended as highly useful VTSs (Brown, 2013; Keating, 2008). The suggestion here is that the participants' mention of games as ways of VL is indicative of their interest in tasks as methods of VL.

Implications of Study

The present study has clear implications to inform practice. As Qian (2004) pointed out, unknown words can be perceived as potential obstacles to comprehension. It, therefore, follows from this statement that teaching effective VLSs will result in improved comprehension. Since, obviously, it is not feasible to teach all the vocabulary items of the target language (TL) to the students, it is then reasonable to predict that capitalising on teaching VLSs instead of spending too much time and effort on teaching vocabulary items themselves can result in more effective lexical learning. This conclusion is warranted and can also lead to learner autonomy in VL as pointed out by Wei (2007).

Additionally, the learners' slight tendency to use dictionaries is of significance with the implication that learners should be made aware of the value and importance of dictionaries in enhancing one's lexical repertoire.

Limitations and Suggestions for Further Research

Further research, as Saunders (2013) asserts, is expected to focus on whether students' self-reported VLSs are effective or not. Indeed, this advice, therefore, calls for experimental research on VL. In addition, future research can be directed at exploring the possible relationships between such variables as learning styles, multiple intelligences and personality types and VL. Previous research has provided some evidence but there remains much to be explored (see, e.g., Golaghaei & Sadighi, 2011).

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Biographical note

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Fereshte Rajabi holds an MA in Teaching English as a Foreign Language (TEFL) from Arak University, Iran. She has previously worked in the Library of Foreign Languages and Islamic Resources (LIBFLIS), Iran, as the administrator of Digital Resources section. Her research interests include discourse analysis, media studies and sociolinguistics.

Appendix A. Interview

1. Describe three vocabulary learning strategies that you consider effective.
2. Describe three vocabulary teaching strategies that you consider ineffective.
3. Describe three vocabulary teaching strategies that you consider ineffective.
4. How important is the role of the teacher and learner in vocabulary learning? Assign a percentage to each.

Appendix B. Vocabulary Teaching Class Observation Checklist

No.	Technique	Yes	No
1	Teacher explains the (new) words in the foreign language.		
2	Teacher explains the (new) words in the students' native language (i.e., use of translation).		
3	Teacher draws figures on the board to explain the new vocabulary.		
4	Teacher uses body language, gestures and motions to explain new words.		
5	Teacher asks one or some students to explain words to other students.		
6	Teacher asks students to make guesses as to what the new words mean.		
7	Teacher asks students to look up words in their dictionaries.		
8	Teacher shows pictures to explain new vocabulary items.		
9	Teacher uses example sentences to explain and contextualize new words.		
10	Teacher tells a short story, an anecdote or a joke to explain new words.		
11	Teacher associates new words with previously learned words to explain meaning of new words.		
12	Teacher asks students to make a mental image of something or someone to explain meaning of new words.		
13	Teacher groups words under one topic and attempts to relate them to each other in terms of meaning on the board.		
14	Teacher uses objects in class and realia to explain meaning of new words.		
15	Teacher contextualizes meaning of new words by bringing new texts to class and reading them aloud.		
16	Other:		

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Interview with Michael W. Apple[1]

Janez Krek

Janez Krek: Dear colleagues and distinguished participants, all very welcome. Michael W. Apple is the Professor of Curriculum and Instruction Theories and Educational Policy Studies at the University of Wisconsin, USA. In his research, he focuses on the critical analysis of the relationships between knowledge and power in schools and in society, and on the issues of the democratisation of educational policies and practices. As early as in the second half of the 1970s, he established himself globally with his critical theory, and is one of the most cited authors in the field. He received numerous high awards at home and abroad for his work. His monographs *Ideology and Curriculum* (Routledge 1979) and *Official Knowledge* (Routledge, 1993) are included in the international list of the most essential books in the field of educational science of the 20th century and, with his entire opus, he is ranked among the fifty most influential contemporary authors in this field. Michael W. Apple's findings have not only become internationally acclaimed, but have also, in the last three decades, become part of the knowledge that we impart to students in certain subjects of fundamental education studies at our faculty. Michael W. Apple has also served as a member of the editorial board of the CEPS Journal since its founding. We are very glad that the University of Ljubljana has awarded him an honorary doctorate today.

Dear colleague and distinguished professor Michael Apple, we are very privileged to have you here with us and to discuss with you about your theoretical work. However, before that, I would like to ask you to begin with some words about yourself and your life experiences which seem to be very connected with your engagement in education.

Michael W. Apple: Forgive me, but I must speak in English. I am from the United States, and we assume that the rest of the world will speak English. Let me tell you a little bit of my biography since I don't think you can understand

1 On 6 December 2016, at a formal session of the University Senate, the University of Ljubljana awarded Professor Michael W. Apple an honorary doctorate. He was nominated for this most prestigious university recognition by the Faculty of Education, which submitted the proposal in view of Michael W. Apple's outstanding and internationally acclaimed research work in the field of critical theory of education, and for his cooperation with the Faculty of Education of the University of Ljubljana. After the bestowal of the title, on the afternoon of the same day, we invited Michael W. Apple, as a visiting professor, to a seminar for students and the professional public, at which an interview and a discussion were undertaken with him. The transcript of this event is published here.

my work unless you see it as embodied in particular instances.

I am the first generation to finish secondary school on time in my family. I come from extremely impoverished backgrounds and from schools that are famous for people going to prison. My brother and I were among the few white children in one of our schools, and the majority of children did not graduate and wound up in state penitentiaries. But I also come from a family of three generations of printers which is the most radical union labour in the United States, except perhaps for women's labour in the garment industry and the textile industry. That's very important because in order to understand me; this requires a sense of printing being the occupation in which critical literacy is what gives it its meaning. It is about the written word. I went to undergraduate school all at night at a small state teacher's college while I worked as a pressman, as a printer during the day. But it is also a history in which such work was strongly unionised. Added to this is the fact that I come from a communist family (but one that was not simply content to follow what the leadership of the Party said). My father came from a Socialist family but later in life became a Maoist. Finally, even though my mother never completed secondary school, she was an anti-racist and anti-corporate activist whose life was organised around mobilising with others in our very poor community to try to make life better and more equal.

I mention this in part because I am carrying a particular tradition that says that education is not simply for economic mobility but that the written word is to be cherished and cultural forms are absolutely central to paid labour and to understanding who one is. Let me move on to other parts of my biography. Before I even finished my undergraduate degree, I became a teacher. Oddly, the army made me a teacher, so you're looking at sergeant Apple. It was not my choice to be in the army at all, but you went to jail if you did not join the army. It was forced. They've trained me as a teacher. After my army experience, I went back to teach in the same poor slum schools in which I had attended as a child. This is crucial. In order to understand my critical work, it has part of its beginnings in reaction to the way in which I as a poor and working-class child was treated as if I did not have a brain. The assumption was that we were not as smart as other people, that we could not do serious mathematics or science and our task was simply to be trained as low-paid labour. It also meant that when I went to be trained as a teacher we were treated in exactly the same way. So, my undergraduate degree is at the lowest level of higher education possible at a small night school. All the courses were organised so that we received lower skills and knowledge and focused on practical skills. The course names signify this. There was 'Physics for Teachers', 'Philosophy for Teachers', 'Mathematics for Teachers', everything for teachers. The assumption being that if you're going

back into these same slum schools, as long as you could read the textbook, had some skills, and had the official piece of paper that said teacher on it, that was enough. Thus, part of the radical position I want to take now, one that I'll go on in few minutes to explain, is in reaction to that. It's part of the basis of my worries that one of dangers of some current critical theoretical work is the assumption that theory is somehow up here, disconnected from the reality of people's lives and certainly in my case it is exactly the opposite. It is partly in reaction to the way in which oppressed people, poor men and women are treated by school systems. There's a robust literature on that to say the least. This is definitely NOT meant as an anti-intellectual position in any way. The basis of my work also is grounded in some crucial theoretical traditions. Thus, while I ask 'simple questions' about the political, ideological, and conceptual groundings of dominant educational and social policies and assumptions, these come from other education I have had. For example, I have a master's degree in Analytic and Continental Philosophy, so I demand a sophistication that I think is missing in all too much current supposedly critical work. I also have a doctorate that involved a joint degree in Philosophy, Sociology and Curriculum Studies. But again, remember that I'm also the former teacher and vice principal of elementary, middle, and secondary schools, so I always want to ground my work in particular kinds of things that involve an epistemological and political commitment that the best theory is done in relationship to its object—school, communities, social actors, curriculum, teachers, policies, and practices. I have two agendas: The first is understanding how power works and the creation of inequalities, understanding why teachers are treated so poorly in so many nations, and why poor people and minoritised people are demonised; the second is trying to figure out how to change these conditions, to interrupt them. So, while I do academic work, it is academic work aimed at social transformation. The simple questions I ask are these: whose knowledge is taught; whose knowledge isn't; who benefits from the way this society, including your own, is organised; who does not; and what can people in education do about it and why should we focus on education? I ask these because I think that education is fundamental to social transformation, something that I argue at much greater length in a series of recent books. Is that enough for now?

Janez Krek: *Yes, thank you, it's been very illuminating. Now, I will start with some very basic questions. In Slovenia and in Central Europe, it is common to use the term 'pedagogy'. This is not the case in the English language, culture and educational theory, where 'education' is the more common, overarching term. You have nonetheless obviously decided to use 'pedagogy' in some crucial concepts that*

define your work, such as 'critical pedagogy'. What is the meaning of the term 'pedagogy' in your theory, and why is it used? How would you define 'critical pedagogy'?

Michael W. Apple: There're two philosophers that I think are very useful for one's thinking about this. One is Austin, and the other is Wittgenstein. They both make a case about how you understand language. Their position says this: don't simply ask for the meaning of words. Most words that are important are what are called in English and sociolinguistics 'sliding signifiers'. That is, they're empty, like glasses into which meaning is poured. In this case, the word is pedagogy or education. And the question we should ask is whose water gets poured into it. The best way to begin to answer this question is to focus on the use of the term. That means you must understand the history of particular terminology and why there may be differences in our nations, but also differences in people's careers.

I have historically not used words like pedagogy. Take as an example my book *Teachers and Texts*. It doesn't say 'Pedagogy and Texts', it says 'Teachers and Texts'. So up until recently – in *Ideology and Curriculum*, my first major book published in its first edition in the mid to late seventies I don't think the word pedagogy is in there. And that is because I come from a tradition of anti-racist and anti-capitalist work where teaching was seen as a broad term. But behind this is also the fact that in the United States and many other nations, teaching was seen as connected to women's paid work. The vast majority of teachers are women and they call themselves teachers. That particular word was and is a demand for respect. It was grounded in a view of teaching as a profession. -This is a complicated history and I'm not totally in agreement with that depiction with what is happening to teachers, but the word is still important. A more substantive understanding would require much more than simply an account of the history of professionalism and its use. But it would certainly need a substantive understanding of gender and class – and race in the US. But no matter what, we still need to see it as a demand that the word teaching should be used because it was connected to people's daily lives. Words such as 'pedagogy' were not prevalent in the US. 'Teaching' dad a long history in anti-racist work and in the history of gender and class struggles for equality.

I'm one of the people who (along with Rima, my wife who is a well-known scholar in the history of women's health and women's studies) is committed to listening carefully to the ways in which 'ordinary' words get turned into partly 'counter-hegemonic' words in real day to day struggles by oppressed groups. This is partly connected to the fact that while both Rima and I are

political activists, a politics in which the politics of language often plays a key role. My activism is also linked to the fact that I am a former president of a teachers' union – not a 'pedagogues' union. The use of 'teacher' continues to connect me to the history and current struggles over demanding respect for teachers. This can be seen in my work over the years. From the very beginning, to me the words 'teaching' and 'education' were more important. The word 'pedagogy' only later enters my vocabulary in a more powerful way.

After the translation in Brazil of a number of my earlier books, I was asked by Paulo Freire to come to Brazil – and his term was not 'teaching', it was 'critical pedagogy'. It had a more Latin-American and European connotation. In my discussions with him over a number of years, it was clear to him and other activists there that the word pedagogy was not simply the act of 'teaching', it also was a theoretically rich word that also embodied social settings, social connections, and institutional and political forms and practices inside education. It was different than didactics, which was more affiliated in some ways with a sense of teaching as a method. For me, teaching was never reduction to a method. It was a broader term. But as I began to work with Paulo Freire, in part because of that book *Teachers and Texts,* which was translated in Brazil along with *Ideology and Curriculum* and *Education and Power*, and I too began to see more power in the ideas behind (critical) pedagogy. My books became movement books as they did here in the mid-'90s. Paulo Freire asked me to come. He was the father of critical pedagogy and the genesis of this more politicised understanding of pedagogy within Latin America. Working with Paulo was significant on both of us. One of the reasons I was invited was not only because a number of books had become 'movement books' and had become very influential there.

There were also more practical reasons. Paulo had correctly brought in many militants, most of whom were male, into the Ministry of Education when he was elected as minister of education of Sao Paulo. He brought in many people to transform schools. Well, that's interesting since they indeed were mostly men. The book I noted earlier, *Teachers and Texts*, is about the history of how teaching becomes women's paid work. And when something becomes women's paid work it gets less respect, less autonomy and historically less pay. In addition, it also gets blamed for nearly everything that is wrong in society. So, these men went in and had a tendency all too often to be less than respectful to women teachers' understandings and skills. Let me say first that I have an immense amount of respect for the dedication and hard work of these militants. They were often brilliant strategically and very smart politically, but they treated women in the same way that too many ministries of education did which

is: you teachers don't know what you're doing. So, I was in part brought in by Paulo to act as the… in English we have a word called 'buffer', which means the safe space in between things. Thus my task was to act as this puzzling 'buffer' position, to tell the male militants about women's paid work and to help to create a more respectful environment that was still very critical but did not act to alienate some of the groups of teachers who were essential to the task of building a more responsive and counter-hegemonic education. That's a little strange especially since as I noted my wife is a professor of History of Medicine and Women's Studies. It would seem odd that a man was brought in but, given the machismo culture of parts of Latin America, it would be accepted if a man said it and not accepted as much as if a woman said it. I certainly dislike that, and, honestly, I'm not certain it was a wise choice for me to do that, but it was effective. So, I began to be in an institutional form where critical work in education is being done, but it was called critical pedagogy not 'teaching'. – As you can see, this is the context that gave particular meanings to these words.

But there is an additional context. Whether I like it or not, 'critical pedagogy' has been the phrase increasingly used internationally for the broader issue of critical education. Its development, by the way, is not in schools at all. Rather, historically, its use is grounded in the educational approaches developed from working with peasants who have dropped out of schools and later become engaged in critical literacy practices in rural communities. The use of it involves a paradoxical and very contradictory assemblage of political uses. Much of its history has been evacuated and has been turned into a set of slogans that has been all too often disconnected from its roots in radical policies and practices. Speaking honestly, unfortunately it's then appropriated by upwardly mobile academics to pretend that they're doing radical work in the United States. It too often involves a search for prestige.

To talk about 'teaching' has less prestige because the word itself is 'teaching'. That's a low-status area, one seen as partly feminised given particular patriarchal assumptions guiding the academy and its hierarchies, certainly in my own nation. But if you could say 'pedagogy', it has some sort of Greek inflection, and it makes it seem as if one is higher status. 'I'm a pedagogue, not simply a teacher'. Again, I want us to think about the use of these words. This is where Bourdieu is very wise as a sociologist. The ease with certain academic talk is represented in one's ease with the body and with established forms of high-status cultural capital. It acts as part of a conversion strategy. If I'm in education – that's nice. But if I'm in pedagogy – that's much better, especially if one is in an already lower status academic discipline. In order to make a difference and to interrupt this conversion strategy, I had to create a phrase such as 'critical

educational studies'. This was created to include both academic work and work in schools. In doing this, it also called upon me to use the language that began to circulate. Even though it basically had little meaning different than 'teaching' when it was imported into the United States, this is pedagogic language. I want to use the language of 'pedagogy' and especially 'critical pedagogy' in a way that moves it from being largely about the ways that middle-class academics solve their problem of class mobility within the academy to restoring its political history and groundings in real life. If you know my most recent work, I have criticised many of these largely rhetorical positions within the existing critical pedagogy literature very strongly, even if I'm one of the founders of what is called critical pedagogy in the United States. I've spent a lot of years criticising the way that term is used since I come from being a teacher, and I think that our work – I am what's called a critical materialist – should again be grounded in an epistemological position that the best theory comes from being engaged with the object of one's theory, which is schools, curriculum, teaching, and literacy practices for me.

So, I hope that you will forgive if I get a little upset by people who continue to have these incredibly abstract discourses about critical pedagogy. Theory is of course absolutely essential to critical work and to continuing the traditions (the plural is important) of powerful analyses. But when I look around, too often what has been done is to 'academicise the political, rather than politicise the academic.' Because of this, I remain worried that a good deal of the work in critical pedagogy tacitly functions as the reproduction of prestige hierarchies in universities. Let me be clear that it doesn't have to do this. When Paulo Freire and other folks used that term – and the tradition of the use of the term 'pedagogy' here – it is a richer term. But when it is imported in the United States and England and elsewhere, it's made safe. It's simply used to say: look at me, look at me, how sophisticated I am. I find that troubling because I'm an educator, and I'm quite proud of that. Thus, while new words are indeed important, at times, I prefer to demand respect for the words that are used and have a history in my own nation. I don't want to claim that we shouldn't use pedagogic words but certainly in the circles that I participate in the word 'pedagogy' (especially when it is paired with the critical) has now too often been made simply rhetorical, safe and limited. I know few teachers who talk about pedagogy. I know teachers who talk about teaching and curriculum. And about communities. And those are more specific. The tradition here and in Latin America clearly is a richer sense of that. But in my own historical and political context, I would prefer to use the language that has not been made safe, that is not too often masquerading as radical.

Janez Krek: *In the last four or five decades, the period since the beginnings of your theoretical work, a great deal has changed in the world. What are the most important political or/and social changes and the most notable theories (or authors) that have influenced your theoretical work in this period?*

Michael W. Apple: We can start out with a book that again took me seven years to write. I started it in 1971, and it was published in 1979. That's *Ideology and Curriculum*. And again, all of these things are intertextual. I was responding to traditional Marxist debates about education. Those traditional debates were influenced by limited or simply bad readings of Marx. Often – but not always – they assumed that education simply was a mirror of the economy. The economy was only represented by its male proletarianised labour, and it was determined by what is called the automaticity thesis – that is it's automatic. If you all get poorer and poorer, you join revolutionary groups and overthrow capital. It's some sort of an automatic response that naturalises the process of transformation as an already known teleological dynamic. That means that cultural form and cultural content and the state and cultural/political mobilisations etc., are relatively inconsequential, they're less important. In these accounts, schools only reproduce class relations. I felt that that was inadequate, and I was strongly influenced by people within the multiple Marxist and neo-Marxist traditions that said culture counts and counts in incredibly important ways. This means that schools could not be ignored. Under previous theories, the best example would be something like Bowles and Gintis and their book *Schooling in Capitalist America*; these had what is called 'identity theory', which says this: nothing that goes on in schools is important except for a hidden curriculum. I'm also a theorist in the hidden curriculum, I think it's very important, but to them it makes no difference what you teach – whether it's working class history or people's science or mathematics for social justice. It's 'nice' to teach these things, but it makes no difference in the world whatsoever because you have to focus on the paid economy. This obviously is quite gendered. They hardly ever talk about women's unpaid work and so many other things.

The sense was that the only important thing that the schools would teach would be this hidden curriculum of docility: doing whatever people in power need and that was differentiated. Rich kids get autonomy and get whatever they want; poor kids get told to shut up. It's more complicated than that. And they forgot about key Marxist concepts like contradiction, and neo-Marxist ideas about the power of culture. People were basically seen as puppets. Whatever capital needs – schools do. As I mentioned earlier, I spent a number of years teaching and was a militant within teacher unions. That experience is carried

with you. Thus, these reductive and largely mechanistic positions seemed like an inadequate understanding of what was going on.

I was influenced by Antonio Gramsci, who argues very strongly about the nature of struggles over common sense. Indeed, if you want one phrase to describe much of my work it can be contained in one sentence: I am interested in the nature of common sense. How it works, how people get convinced to go to the Right – these are words to talk about later – rather than to go to the left. For instance, in my own nation, we now have an incoming president called Donald Trump. (Perhaps I should consider moving to Slovenia? That's not a joke. The fact that I've been here since '89 also makes me feel at home here.) There is an important issue in which I am interested in: how is that possible? Gramsci argues very strongly that the nature of common sense is contested. There's no such thing as false consciousness – people are not puppets. They have elements of good sense and bad sense. The task of dominant groups is to attach themselves to the elements that are 'good' in people's understanding. I wanted to merge that with my training in phenomenology. I have both analytical and philosophical background but also training – education – in more continental forms. Habermas was very influential on me and not Husserl at all since I think it's quite romantic in some ways and impossible to achieve. The transcendental epoche' seems like a bizarre concept to me. We may have an argument about this later. But I'm interested in people like Alfred Schütz who was a sociologist of knowledge, a key part of my background. He – and I – were deeply interested in the question of how knowledge is distributed, whose knowledge is there, the legitimation processes of knowledge, so that's informing me. The first series of my books are also informed by that issue.

A third person who was very important to me in my formation is Raymond Williams. He, like me, comes from the working class, was a son of miners from Wales, an adult educator who then went on to a Professorship at Oxbridge. He wrote books like *The Country and the City* and also wrote the book that had a strong influence on me, a book called *A Long Revolution* which says that you cannot stop critical literacy practices and people building their own literacy ultimately over a long period, a long *durée*, as it is called in French. In the long *durée*, there are mobilisations that will interrupt dominance. I took these themes up, largely focusing on people's daily lives and culture, with an emphasis on schools. In response to the overly reductive theorists like Bowles and Gintis and similar overly economistic positions that ignored culture, what is actually taught in schools, and the state, my focus initially was on the curriculum itself and how it's organised, which also makes a strong difference on the hidden curriculum and on what is actually taught in schools. In *Ideology and*

Curriculum, as an example, there's empirical work about what happens in kindergarten classrooms where children are taught that what is work is important, what is play is unimportant. If we look at the spatial politics of the classroom, things for play are up high, where the teacher can reach them, things down lower are things for work.

Clearly, students are being taught what is important is work. Because anything that is for play is out of reach. I wanted to show that what goes on in classrooms is actually crucial and the struggle over curriculum is crucial. I made connections with people like Raymond Williams but also other people working on similar projects. Basil Bernstein's work in England was important to me, especially when he said that the way the curriculum is organised, whether it's separate subjects like farm silos, or integrated curriculum, spoke to class dynamics. Thus, if you're an 'amateur' and you have money you can be someone like Darwin. You are funded, self-funded to do immensely interesting research in evolution. But it required you to be rich – to be the rich amateur to do this. I personally have been involved in teaching about and building integrated curriculum, especially critical curriculum. But at the same time, Bernstein is saying that's also a class discourse. Capital has changed, new classes have evolved, the new middle class becomes very important, and they have expertise and computers, accountability, measurement, making advertising. Nearly all institutions are influenced by such expertise. These influences and the power of the cultural and social capital of these emerging new middle-class factions cut across the usual institutional and disciplinary boundaries. This realisation meant that my rather romantic vision of integrated curriculum as being better than something else still reproduced class relations.

This emerging focus of my work then created international connections with a group of people. The analysis needed to be made more complicated. Romanticism, even in the practical political work I was doing, needed to be approached with great caution. But Gramsci also pushes me in ways that remind me of Althusser in particular. That's the notion that ideology is everywhere. Bourdieu as well helps us again to see it everywhere, even in the most mundane experiences of eating, drinking listening to music, etc. However, again I was strongly committed to a position that says people are not puppets. So how would I explain the fact that there are resistances and struggles? So, at the end of *Ideology and Curriculum* I say let us no longer only-focus simply on reproductive forces and dynamics in lived reality, but let's restore agentic work. The word agency will become crucial in a second. Certain people help me think about that.

Let me give an example of how it's important to think about this.

Althusser says ideology is not just in texts… it's not just in the formal curriculum and how it's organised. It's everywhere. Now, that's a very dangerous position to take because if everything's ideological it doesn't give you any purchase on what isn't ideology. It's an important claim, but it's all too general It's like saying everybody breathes. Okay, that doesn't tell me much. But Althusser is saying ideology is everything. So, I give one example: I got a fellowship to study philosophy at Columbia University. It's the strongest philosophy programme in the United States. I had come from night school and had only one philosophy course at night at my small undergraduate college. I passed it, thank god. But I'm now at a prestigious programme in a prestigious university. Think of my experience. I walked into my course in epistemology at Columbia as a first-year graduate student and everyone would have gone to elite universities, everyone but me. They were sitting like this [demonstrates]. Their bodies were comfortable. They embodied an ease of being there and their bodies showed it. They looked totally comfortable. I want you to notice the way I'm sitting here at the University of Ljubljana? Even though I'm comfortable here, I'm with friends and have great mutual respect for my teachers here in Ljubljana, I sit very straight. I don't look very relaxed. Instead, I look very intense, like this. But in that epistemology class at Columbia the meaning of my body was very much related to my social class location and trajectory. If the professor of that class had sneezed, I would have asked him to spell it. Now that experience, that Althusserian moment connects me with Bourdieu as well. The body hexis is this. It is the ease of the body – not just the content, but how comfortable you are with it. That meant the body became more important. But very importantly it also meant that there must be holes in this process of class identity and bodily reproduction, because while I am there in that philosophy classroom., I am also rejecting half of what am I being taught. For me, the entire context is pretentious, a form of elite foolishness. Let me stress that I wanted serious philosophical knowledge. Indeed, I demanded it. But I wanted knowledge connected to daily life; I wanted it to be really sophisticated. But I wanted respect for what I too knew. Perhaps this is why social phenomenology was a strong influence on my work.

In order to understand not just my complicated reactions to elite institutional forms, but also the reactions of so many others, it became even clearer to me that I had to then understand the concept of agency in a much more detailed and nuanced way. Among the more significant books that helped me and others was Paul Willis' book called *Learning to Labor* – a very famous book that could use a little more of a psychoanalytic framework, but it's still brilliant. It argues again the Gramscian point that things are complicated and contradictory,

people can have elements of good sense and bad sense. He studies young men who reject the hidden curriculum in schools but at the same time reproduce it.

That cements in my mind the power of Gramscian understanding. That there are elements of good sense and bad sense. For me then, agency becomes even more important, not only because it enables me to balance the claims of reproduction with those of the inherent contradictions of institutions and daily life not only on an abstract theoretical level (though that was important) but at the level of concrete experience in schools, families, communities, and people's understandings of who they were and what their possibilities were collectively and individually. This opened a door for me to some post-structural analyses and to other people who were 'between traditions' such as Stuart Hall and others. I knew that I had to be very careful here. Some post-structural material is more than a little problematic. And many 'posties' see their approach as a full replacement for more structural analyses. This is a mistake. Foucault is brilliant about many things, but his work is not a full replacement for Marx and the entire set of creative traditions of cultural, political, and economic analyses that grew from that origin. The focus on discourse makes major contributions, but it carries with it a number of problems. Political economy is not a discourse. People are dying, starving, bodies of children are washing up on beaches. We make discourses about such things. But anything that rejects or causes me or anyone else in this room to largely reject a material understanding of reality in connection with cultural forms and internal struggles that are also structured, is damaging.

However, as I said, even with these problems, there are still important things to learn from these theories. Given this, I then turned to and incorporated some post-structural understandings of identity, of discourse and its power on the body, at the same time as I laboured to keep alive the understanding that this is capitalism and that makes a really big difference. But it's capitalism not only for male workers. Capitalism is a class project, but it's also a racial project and a gender project. So, I want to look then at women's agency. To women who learn this hidden curriculum, do they talk back? – Of course, they do. I begin to look more in books like *Education and Power* and *Teachers and Texts* (the latter book being strongly influenced by my wife Rima and her work on the narratives of women's lives) to think about much more substantively what women's lives and struggles are like, what does that mean, how do women resist, do they just internalise these kinds of things or are there elements of good sense and bad sense. This is also accompanied by similar issues surrounding 'race' and how it is produced and experienced. Remember, I had been an anti-racist activist from the time I was a young man, so this was constantly on my mind anyway. Furthermore, as the parents of a Black child, (our older son Paul), and as a political and anti-racist activist, it

was clear to me that young Black men and women do not merely internalise the identities and racialising and gendered forms of marginalisation that dominate our societies. Their lives and lived cultures are filled with complex understandings – and again elements of good and bad sense that can interrupt dominance.

Let me give an example from my own experience as a young teacher in the slums of an old industrial city on the east coast of the United States. Let us pretend that Michael Apple is now back teaching the 6th grade in this very poor school that is filled largely with Black and other minoritised students. And one child says: Mr. Apple, may I sharpen my pencil? And I say: Of course. And the child gets up and his walk to the pencil sharpener takes what almost seems to be three days. He just as slowly sharpens the pencil with a smile on his face like this. That seems to take another three days. And on the way back as he passes by his friend, he hen pokes her playfully with the sharpened pencil. She goes 'ouch!' and he smiles as if nothing has happened. And he smiles back at the entire class – and ironically at me – knowing that he and the rest of the class now have the teacher's attention. That they control the classroom, Michael doesn't. I don't mean this to be cute. I'm trying to understand the daily realities in the ways that ideological form works and what we can do about it. So that requires that I begin to think about identity work. It means that Judith Butler's work becomes useful. The work for instance, of Lacan and other similar theories need to paid attention to (but very carefully). And it means that I have to then begin to think through feminist understandings of bodies, and even more substantively about anti-racist and post-colonial work. This continued openness to multiple critical theories and traditions means that I am a *bricoleur*. But it also demands that I work as hard as possible to take seriously the criticisms of each of these traditions so that when I try to employ, then I am doing so in a manner that recognises the limits as well as the gains of being a *bricoleur*.

I find that a satisfying position. I have two legs. One and a half of them are within Marxism and the Marxist and neo-Marxist traditions, from the original texts, actually. I want to return to the original texts of these multiple traditions whenever possible, in part because I think there's a lot of sloppy and quite reductive and essentialising work that is now being written that misreads these texts and uses them for rhetorical purposes only. Yet, at the same time, there's a half a leg remaining that constantly kicks me and says that's not sufficient. That seems to me to be a very wise thing. Since the world in which we live is constantly in motion and at times is being fundamentally transformed. This is especially crucial now because of one major recognition. As conditions change too many of us tend to assume that revolutions always go forward., Yet, one thing that is increasingly evident is that it is possible – and real – and is

exemplified in the growing hegemonic influence of movements of what we can call a 'conservative restoration' or conservative modernisation. This is something I am deeply committed to understanding – and to interrupting. I'm interested in how revolutions go backwards. Clearly, I've always been interested in differential power. But the ways in which this works under current neoliberal and neoconservative conditions requires that our theories and analyses become much more nuanced and subtle, not simply a return to rhetorical slogans. We need to show how the agency of dominant groups (again the plural is absolutely crucial) exercise agency. We need to see them as engaged in a very creative cultural, political, and economic project – basically involving a creative social pedagogic project of changing our common sense fundamentally. Because of this, in the last two decades, I have focused on the political Right. People like the person in Austria who has now won. I'm interested in the way in which rightist mobilisations occur and that requires that I think about identity, how masculinity works, how the use of the racialised 'other' plays a major role, the ways in which class understandings can be and are altered and mobilised. That's been the kind of trajectory I've been on. I'm now trying to figure out how did the Right do what it did and then use that understanding to learn what can be done to challenge them successfully.

All of this is because they have taken all of these dynamics and have pushed people in a direction that I think is murderous. All of these issues about agency, about people's identity, about the curriculum in schools, about social transformation, come together here. What I want to argue is – what I want to understand is – how to change these kinds of things, what can progressives learn from the people on the Right who have proven to be very good at it. In my mind, Gramsci was correct. Dominant groups work off of the elements of good sense. This needs our very best theories and actions.

Janez Krek: *It is obvious that right-wing neoliberal policies have introduced the most important political changes in the USA and many other countries in recent decades. From our perspective (Slovenia as a part of Yugoslavia until the beginning of the 1990s), another political rupture should be mentioned. From the 1980s to 1990s, Yugoslavia disintegrated, and the Eastern Block collapsed, China turned into an unprecedented mixture of the 'Left' Party'-rule supporting 'primary', neoliberal capitalism. Did these changes in political and social paradigm also mean a change in understanding of the 'conceptual position' of 'critical pedagogy' for you, especially in relation to Marxist theory as a source of political theory's vision and emancipation? Did these paradigmatic changes have some impact on your 'critical theory', a change of perspective on what is important in education?*

Michael W. Apple: This is a complicated issue. I mentioned that I've got two legs. I don't want to throw out Marxists' concerns. But I think that within the Marxists traditions there are analyses that are absolutely central to the work I want to think about. But there's not a single Marxist tradition. I think that it's a false claim to assume that there is. There are certain tensions and tendencies within Marxist traditions. There's been a resurgence of voices who sound like Second International Marxists, who simply (and wrongly I think) claim that it's all the economy all the time. There're others who look at intersections of the state with economic form and class dynamics. This seems wise to me – if we remember that class occurs in raced and gendered bodies and that these dynamics have relative autonomy. But I also want to claim the following: two class models are insufficient. That capitalism has been radically transformed and I think it is a magic trick to assume that we can use 19th-century models of class dynamics to fully understand today's national and international realities. We need class understandings powerfully – class has not gone away, but it has become much more complicated. So, I want to look at the intersections between the state, culture, and economy. And I want to look for instance at the ways in which certain class fractions, the professional managerial middle class, have actively colonised the sphere of educational policy within the state apparatus. That is required because I think we need to focus on the realities of audit cultures and measurement, on the prevailing disrespect for teachers, on the belief that everything must be seen as good or bad because of PISA scores. This cannot be understood as simply due to the ruling class and its overt interests. Of course, I think there, of course, are relations of these things to deep structures. And in order to see this, we have to say what's the engine that causes this? And I want the engine to be made more sophisticated. That requires that when we do the class analysis that we ask who are the classes in power in particular segments. And if I'm interested in education, it's not only economic capital and its needs. This is where Bourdieu becomes essential to me, I want to think about the intersections of cultural capital, economic capital and social capital.

Whenever we employ Bourdieu, however, we need to remember the limits of his analysis. Bourdieu is wrong when he makes capital into a thing and not a set of relations., Yet, his categories are handy metaphors to think about the way in which control and power work. I want to restore the dynamics, the complex motions, to Marxist's theory, I want to reassert neo-Marxism which asserts that culture and cultural struggles are crucial, that identity is crucial, and that these relations are best understood by seeing them as fully contradictory. As noted earlier, I also want to say that when you look at education policy in particular, that it is not simply a reflection of a two-class form. That there

are relatively autonomous class factions, the new middle class, in particular, that has extraordinarily powerful forms and content. So, in addition I'm making a criticism of traditional Marxist's theories. The Second International forms of Marxism that many people like McLaren and Giroux argue for are simply rhetorical. But even this is not enough. I want to ask another absolutely crucial question: is it all about class all the time? In the United States, for example, whatever we have – including my ability to do my work – is dependent on the history and current reality of capitalism as a racial project. The nation was built on Black enslaved bodies. There'd be no nation without slavery. What does this mean? Let's think about what's the ways in which modern political economies have their basis in the unpaid labour of enslaved people, on the genocide of indigenous peoples, on the unpaid labour of women at home and on farms, and on the exploitation of women's work in the paid work places that have been dependent on that exploitation and disrespect. Thus, I don't want to ignore the economy, but I want to think about what are the ways in which race operates? Because the US has an internal and external empire, and it always has. And the US has a long history of struggles over gender relations and inequalities and this must be considered in truly constitutive ways.

How is it for instance, that we are now more racially segregated in the United States in schools than ever before? That one of every four African American young men in my state is not in school but has been or is now in prison. That's not just class. I want us to think about what are the ways in which multiple dynamics intersect and work under what we call the political economy and cultural struggles. Thus, I think that the state is not just a capitalist state; itis a gendered state and a racial state. An example would be right now in my own state of Wisconsin – which is, by the way, historically the home of what is called 'American socialism' and is supposed to be the most progressive state, there's more money spent on prisons than on all of higher education combined. And 80% of the people in prison are Black young men and women or indigenous or Latino.

That's the demographic data. And it should lead us to ask the question of whether this is an accident, is that because of class? Part of it is, we have deindustrialised the urban and rural areas, the factories are closed so poor white working-class men and women are now employed as prison guards to guard poor Black young men and women. I want to look at what's the intersection here? Capital is shedding labour and then giving jobs that involve the repression and incarceration of Black men and women. To do that I have to expand my understanding of capital and I have to look at how do schools work in such a way that minoritised children are basically pushed out? Not kept in schools.

What's the curriculum doing? How would we change that? Because I am a critical activist in education, I want this to come back to schools; but, then again, I want to do it in a larger context. This also means I have to look at not just what is someone or some groups are doing and not just who's in charge, to highlight the agency not only of dominant groups, but just as importantly the agency of oppressed groups as well. This means focusing as well on who's doing the interruptions. Who's acting back? And that means I have to think not just about class and its supposed centrality in every situation, but, in this case, if you're talking about race and the social movements that have been formed that deeply challenge the racial state and its policies and practices.

It's groups of Black young men and women and parents and Latino and indigenous people saying, 'You can't do this to me anymore'. These movements extend beyond their class location. No matter where they work since many of them may be middle class – I have to ask about social mobilisations and social movements that are class based, and race based, and gendered/sexed based as well as ones that are complex in their composition. This also needs to include movements that have religious forms as their basis, as we shall see.

This focus on social movements is crucial not 'only' because it allows us to see the agentic work of oppressed people. It also allows us to much more fully understand the Right. I have to look at the Right. Since the Right is not just capital, it's conservative religious activists. It's anti-immigrant activists and while it's partly about class, it's not only about class. It's also about threatened white masculinity and white dominance. About the fear of the Other, it means I have to expand who the actors are. And that means I have to focus on – in the United States for instance – issues of racist behaviour now increasingly present in the larger society but also the ways in which ultra conservative religious forms and movements have been increasingly influential in schools and now in the state and the economy.

This, of course, is now truly international. How would I understand Pakistan, Israel and its miserable mistreatment of the Palestinians? How can I understand that the curriculum in many Texas schools now says the following: evolution didn't occur, and that global warming is a fiction? That's not simply a class discourse. How would I understand that in Texas teachers can get certified as science teachers of Physics and Biology and Chemistry not by teacher colleges, not by the University of Ljubljana and its excellent programmes and history? They're certified by the Institute for Creation Science which says that the Big Bang never occurred, that the Bible says that the world was created in 4004 B.C. and that there is no evolution whatsoever. And that there's no climate change. I now have to employ a considerably broader vision if I want to think

about schooling and politics of interruption. I want to say hmmm, who's doing the interruption now? What actually is the Right? How has it changed in both its composition and its strategies? And that requires that I add more lenses to see reality and that I think not just about structures around class and gender and race but about the ways which these dynamics are organised and by whom. This places social mobilisations and social movements that now have increasing power at the centre. These movements are more powerful on the Right, but they are certainly growing on the Left as well. I still keep my focus on the things that I thought were important before but now I have had to add some more. That's really complicated. But so is reality.

Janez Krek: *In your quite recent book Can Education Change Society (2013), and in other works, you use the terms Left and Right, terms that many now believe have less and less sense and a less clearly defined meaning. Let's leave aside what defines the Right. How would you define what – if anything – characterises the Left in our contemporary world? Does it (or how does it) still exist as a kind of political entity with a programme?*

Michael W. Apple: Remember I started out by saying don't ask for definitions, look at how the words are used and by whom. This becomes a good example: the Left is fractured for good reasons and bad reasons. But good reasons do exist, and it may be necessary that the Left has had internal fractures. If everything is determined by class, then it is all too easy to assume that women's issues and issues involving immigration get solved later after the revolution. I'm more than a little tired of people telling women, folks who are gay and lesbian, and people who are seen as institutional others: wait, we'll get to you later on! I think that's bad politics; I think that's very bad tactics. What I call the Right actually is willing to compromise among itself. And too much of the Left still has this vision of a search for purity. I think that the search for purity is actually a problem. It's a danger. I have this phrase as you know called 'decentred unities'. I want us to think about what binds us together but not under my or one single leadership. This must be the result of ongoing collective and participatory deliberations and agreements.

At the same time, I think that the Left has been subjected to internal divisions and drifts that are very damaging, but at times they were necessary. Again, let me give an example. Some of you know I've spent a lot of time in Korea, I was arrested in Korea and some of my friends who are quite radical were arrested with me. I was giving a talk like this and I, unfortunately, said something about military governments. In some ways that may not have been

smart. But on reflection, I would still do it. Think of Turkey now, that's what it felt like but worse. My friends who are very militant had a tendency to tell the important women's movement that had emerged in Korea that this would change after we change everything else. That really is disrespectful. And as I have repeatedly said here, it forgets that capitalism is also a gendered structure. It requires unpaid labour, domestic labour. -women, almost all women, have two jobs, paid and unpaid. Capitalism depends on the unpaid labour at home. Look at neoliberalism, an ideological form now increasingly dominant in the West, in Germany, France, England, in the old empires which are trying now to reassert themselves, and the United States. Neoliberals – that is, economically dominant groups and their allies – are saying the following: it's too expensive to have health care, care for the elderly, people with Alzheimer's, people working as youth workers in communities… we can't afford that now.

But all of this work still needs to be done and guess who does it. The unpaid labour of women at home. So, if your relative can't get health care, guess who's supposed to do it? It's women. In many ways I want to say that the Left disintegrated not simply because it was wrong, but because part of it was transformed by real progressive social movements that understood the structures and processes that were also fundamental to our societies and their relations of dominance and subordination – and it needed to be transformed. But this continuing transformation also created a great rift and fracturing. The reality of having multiple progressive projects is the reality now and is actually something that ultimately will strengthen progressive forces in the long run. The project for instance of transgendered people is very important, the issues of sexuality and the body are important. The Black Lives Matter movement in the United States is teaching all of us how to mobilise effectively against multiple relations of dominance. The issue is how do we see the inter-relations of these movements and struggles so that we can form alliances across our differences and work together for a more emancipatory critical democracy.

Here's another example of how to think in ways that show the connections of different dynamics and the importance of building alliance. Rima and I were working in South Africa, and we went to some schools, and there were few or even no teachers in many of them. One third of the teachers are gone. Why? Because they're dead. Why? Because big pharmaceutical industries from Germany, from the US, from Canada, from England, demanded profit for drugs. Yet, no-one has to die of an HIV infection. Zero. These teachers died because their salaries did not enable them to afford the prescriptions and the government and especially drug manufacturing companies refused to see that it had a responsibility for the health of these people. It became clear to Rima and me

that we needed to see intersections between the issues of the body and people being killed and profit motives. If I was interested in schools – and the fact that there's no teachers in many schools – issues of sexuality, of men's treatment of women and the spread of HIV infections, and the profits of large drug companies – all of this had to be combined. And movements around each of these needed to work together if this situation was to be transformed.

Thus, in many ways, I want to applaud those people that challenged the traditional Left – as long as they also showed respect for the gains that were made under what is traditionally been political economy and class analysis. And because I want to demand respect for all of the gains that were made, and that are still necessary, I want to use the word the Left out of respect for what formed me and because I think, as well, it is still absolutely essential. But almost every time I use that word – the Left – I put in mental quotation marks. Because to me the word 'Left' is now this sliding signifier. It has no real centre, and that's a good thing as well as the bad thing. I would usually now call the Left a larger 'progressive' (decentred) alliance that is committed to a broad range of emancipatory projects. But I have to be very cautious in using the word 'progressive' here in Slovenia, especially in this entire region. Because there are progressive parties in Austria and in Serbia and elsewhere where progressive means as retrogressive as you possibly can be. It can mean right-wing populism, a very dangerous phenomenon that I now need to talk about.

Rightist populist mobilisations are now present and increasingly powerful in multiple nations. So we're now searching for a word that describes this set of alliances where people are saying what Nancy Fraser says in *Unruly Practices*: there are three kinds of politics that are essential to anything that is progressive: a politics of redistribution (the traditional left), a politics of recognition (which is about respect and cultural forms and which also may require structural changes including economic, ones) and a politics of representation and voice. To me, it's putting those three together as progressive mobilisations that are important. Yet, we need to remember that the Right is equally complicated. It too has demands in each of these spheres. In books such as *Educating the Right Way* I document how the Right, not just the Left, has changed. the Right has changed. It, too, has incorporated 'populist' messages, forms, and attacks. Here again, I have been strongly influenced by Gramsci and his analyses that modern forms of dominance work through what might be called a hegemonic block and alliance, an 'umbrella' that multiple groups can coalesce under. I want to think about this as an umbrella.

Let's examine this. Most of us would agree that it's raining a lot in education, social welfare, the economy. Most people want to get out of the rain, but

there's a large number of ideological umbrellas out there. There's our umbrella: show respect, pay people enough to live on, stop exploitation, no more racism, colonialisms are a bad thing, women deserve equality, and many more. This sense is the same that Nancy Fraser has argued for. There's a politics of redistribution coupled with a politics in which the body and cultural forms and identities are central, and a politics of representation and voice. These are interwoven, and each is important to human flourishing.

The Right recognises that there's multiple umbrellas. If I want you to come under ours (the Right's), I have to convince you – what Althusser called interpellation – to do this. Yes, it's raining, so for parents it is raining, and there's no guarantee that their kids will do well as universities cost more and more outside of Slovenia, and it may be temporary in Slovenia that there's no big fees, because the rest of the world is moving towards fees in almost all institutions of education. Teachers would say it's raining because their pay is not being increased, they're losing their autonomy. Capital says it's raining in education – and I quote now – schools are like black holes, you pour in money and PISA scores don't come out. So, it's raining. Thus, the task is one of ideological convincing. The Rightist alliance engages in that vast social/pedagogic process of generating the discursive force to convince people to come out of the rain under its leadership. It is important, however, to understand that this leadership is not simply one group. The Right has four groups with their hands on this umbrella and they don't always agree with each other. One is neoliberals: private is good, public is bad, corporatise everything, shrink state funding for education and give it to the private sector. Our new secretary of education in the United States – a billionaire who is also a very conservative evangelical believes that we must fully support private schools, since supporting public schools as a state function is a bad idea. She also believes that her task is to 'bring about the Kingdom of God on Earth'.

Neoliberals like this secretary of education are committed to a weak state – everything should be as private as possible. This is a very dangerous position. We already know that the private school sector is more class and racially segregated than any other school system in our nation.

There's an influential second group that is committed to a strong state not the neoliberal supposedly weak state, what I call neoconservatives and they want control, state control, central control over culture, and over women's bodies in particular. They are anti-abortion, women shouldn't have rights whatsoever about their bodies and the processes of reproduction. They also have a strong cultural agenda, one that involves a romanticised and deeply ahistorical vision of a common culture and a common set of beliefs that all people must be

taught and share. This is what Bourdieu would call an act of symbolic violence.

There's a third group called authoritarian populists, a term that I draw from Stuart Hall. They believe that 'the people' should decide, but that there's good people and bad people. Good people believe in orthodox religious forms. And the more I can integrate religion back into schools and social policy, the better it will be. That group has the fastest growing school reform in the United States: home schooling. Three to five million children have been pulled out even out of religious schools, they are being schooled in the gated communities of the home, thereby guaranteeing that nothing but religious and very conservative values are taught and are never interfered with by the outside world. Because there's too much pollution outside of kids with different ethnicities, different cultures, different languages, different religious beliefs, we must act to keep the children safe. Thus, they never interact with anyone who thinks differently.

And then finally there's a fourth group in this alliance – the professional and managerial middle class who believe that if it moves in classrooms, measure it, and if it hasn't moved yet, measure it anyway in case it moves tomorrow. Pardon my humour in describing this group's beliefs in this way. But these are people who have actually colonised the educational apparatus of the state. And it's often their policies that are being instituted, not just capitalists. Their mobility and that of their children is based on the cultural capital that they possess, the cultural capital of measurement, accountability, technical expertise, and managerialism. From this we can see that the Right is also complicated. And that means that it is even more necessary to think about hegemonic blocks in which alliances are formed that involve a complex economic, political, and cultural politics and that cut across the landscape of class, gender and sexuality, race, and religion. Given the fact that I have worked not only with workers and anti-racist groups throughout world but socially critical religious groups as well, I don't think it's natural that people who are religious move to the Right. This movement toward the Right has taken an immense amount of effort by the Right to convince people to come out of the rain under the umbrella of what I call *Educating the 'Right' Way* conservative modernisation.

Because of this conservative umbrella, one that is fragile and constantly requires hard work to keep it intact, just like I put the concept of the Left in mental quotation marks, so too do I put the concept of the Right in mental quotation marks. This idea that these Right and Left alliances are fragile is crucial to my thinking about counter-hegemonic blocs. Take the issue of religious groups again. I have worked very closely with base – community movements in Brazil. These are very religious folks, many of whom are evangelicals. I quote from one

of them who said, 'Jesus was the first communist.' That's interesting.

Rima and I have also worked with Muslim activist women in Turkey, who when you look at them are often dressed in burqas, they wear gloves, their ankles are fully covered, many of them have hijabs, and some of them will have even their face covered. I'm ready to say I give up on you. Yet one woman came up to me when I was giving a very critically oriented address in Istanbul a few years ago, introducing herself as an 'Islamic Marxist feminist' and she is dressed in a way that – signifies to me that she is an Islamic religious conservative. Immediately I assume that I know what her position is going to be on so many things. And then she said to me: look, this is my safety net. It's not a women's problem – it's a men's problem. Islam is anti-capitalist by definition. She pulls out her Quran where it says: we will not charge for loans. 'I also am dressed like this because… 'She pauses and then says: 'Look up above you, Michael, there's this objectification of women's bodies.' (I look above me on the street and there's a large sign advertising women in very sexually suggestive underwear and positions. It's a Victoria's Secret advertisement. It's like when you walk through the centre of the city here, and there're ads for Italian lingerie. So, she is objecting to that not because women don't get pleasure by looking nice but because they're saying that this representation of women is what is happening in our nation. Women's bodies, including now very young women and teen and preteen girls, are being used for profit. As she speaks, I too recognise this problem. I also see girls dressed like Madonna when they are 6 years old. It's true, it's happening in the United States. She wants to defend the idea not of women's purity but that we, women, will make decisions about how our bodies are used. And because men aggressively treat women as objects so much of the time, when she's in public, she says look, I'm tired of the fact that when I'm on a bus going to work I'm treated like I'm – I quote now – 'a piece of meat'. That's really powerful stuff. It contains very critical insights into women's lives and how women are publicly presented as objects of male desire in the service of profits. It seems to me that we must ask how insights such as these – elements of good sense in Gramsci's terms – can be employed to convince people that there are better, more socially emancipatory, umbrellas than those of the Right to be used to get out of the rain.

I don't quite know how to deal with that in terms of countering the Right's ability to occupy that space. But I want us to take that issue very seriously so that we can think in more substantive ways about how religious forms work and to ask if it is natural that her understanding of this gets organised around the ultra-conservative kinds of religious impulses. I don't think it is natural. Because I know many people who are deeply religious, the folks who

were arrested with me in Korea are evangelicals. They don't believe in evolution, but they also say, 'capitalism is not God's economy'. Even though it is one of the foundations of many conservative evangelicals that capitalism is indeed God's economy, for my friends from Korea they would have totally rejected this and would have quickly said that- Jesus would've told me to oppose it. I like that. That makes sense to me. This makes me realise that though Left and Right are still useful historical categories, because I want to respect the tradition of the political and ethical differences that lie at the heart of the categories of Left and Right. But they are mobile, not necessarily stable, distinctions. I use them out of respect for the people who were my teachers and for my own work but at the same time I also need to challenge the stereotypes of what counts as Left and Right and treat them as entities and affiliations that can be moved. The Right has moved a large number of people from the Left to the Right. It's clear that it's not a permanent condition. This is one of the reasons I urge scholars and activists in critical education to pay considerably more attention to things that go on outside as well inside schools. I say more about this and about what it tells us about our social responsibility to understand and interrupt dominance given the Right's creative ideological work in *Can Education Change Society?*

Janez Krek: *In the book Education and Power, you write that ideologies 'are embodied by our common-sense meanings and practices' (1982, p. 249). It is not, therefore, simply the case that the revelation of truth brings the elimination of ideological ties, or that people do not know what they are doing (the Marxist idea of 'false consciousness') ... the hardest form of the ideology is faith in common sense, a belief that we are doing what is required of us by 'reality' ... This means that effective anti-ideological intervention cannot be simply criticism alone; anti-ideological operation requires the next step, the establishment of 'hegemony' in the field of discourse, the occupation of the ideological space, which would mean occupying the place of 'common sense', what 'common sense' believes. But aren't these two positions contradictory? – And precisely for this reason, hasn't be Left perhaps always been better at criticism and worse at occupying of the place of 'common sense'? Where are the key points (globally or within the context of the United States) in which there is a need to reoccupy the place of 'common sense'?*

Michael W. Apple: This is among the most important questions that can be asked by anyone as it has to do with political practice. And cultural forms. So, let me repeat one thing. To me ideology is not something appearing in your brain, it's an embodiment. And that's pure Althusser. It's embodied in a way you sit, in the foods you eat, in the way you walk… So, when I gave the example of

the youth in my classroom resisting me by going to sharpen the pencil and then going back and then the slight smile between the two of them as they knew they had taken back some time, we can say that that act of resistance is counter-hegemonic but it's certainly not conscious. It's not saying: I'm going to show the way in which the capitalist hidden curriculum in schools can be interrupted. It's the daily life, it's I'm bored in school, this teacher is boring, I have to have some fun. That is common sense that embodies elements that interrupt dominance and reproduce it at the same time. So, it's not a conscious understanding, but it is again a similar situation described in Paul Willis's analysis of the working class 'lads' in *Learning to Labour*. It's not up here only in one's head, it's in the entire formation.

I start out there. And I want to employ the Gramscian and Althusserian insights in many ways here. As I mentioned earlier, there's no such thing as false consciousness. Consciousness is fully contradictory, and it's not an appropriate way of understanding consciousness to maintain that the idea's up here. I want to say it is the entire body. Not just the ideas we have. But for ease of communication we want to call it 'common sense', in part what Bourdieu has called habitus, but in a much more dynamic way than Bourdieu. It's the way we go about our world. An example would be something like this that I mentioned last night: There're many women in one of my postgraduate classes that meet at night. When it gets late at night and it's dark, many of them have to walk to the bus stop that's four or five blocks away. However, the university has dimmed the lights as you walk on those streets because the electric bill is now very expensive, and the university's budget has been cut. So, they save money by putting in lightbulbs that aren't very bright. When I walk on my way home after class I walk easily like this; it's my space and I do not have any concerns about my safety. Yet, for many of the women in my class, half of them at least, they take out their cell-phones and talk to people as they're walking or if the battery is dead, the phone is still held up to their ear as if they are having a conversation. This is done in recognition that there has been physical violence and sexual violence against women near the university. Unlike the women in my class, my body – the male body – in this space is privileged.

For the women in that space, the use of the cell phone is not necessarily done consciously: it's automatic. Because there's knowledge already in your body that a woman's body in that space is endangered. Even if it never happens, it is always possible. Thus, there's some sort of automatic response that is very powerful. If we think about that, I want to say there are elements in our limbic system; there are elements of good sense. It's a dangerous space, and automatically I do this. Only if someone asks 'Why are you doing that?' is it brought to

the level of overt consciousness. 'Well, I just feel safer'. But embedded in that statement and in the very physical acts with the phone is a profound recognition that social space is fully gendered. It's not the words that are used; it's not conscious in the usual sense of that term; it's not theorised. But their common sense has elements that recognise gender hierarchies and that the act of simply walking home requires caution.

I'm going to use this as a sort of a metaphor of what's going on. It means that I have some faith in some elements of common sense. I do not romanticise it. But I think that it is crucial that we understand that common sense is contradictory – no one is simply stupid about their lives. Too much of traditional Marxist understanding of ideology is 'You don't get it'; 'You don't understand anything'. Somehow I get it, but you don't. Once again, I'm not a romantic, I think people do have ideas and understandings that are fully wrong sometimes. Racist beliefs for example such as a belief that immigrants in the United States are stealing people's jobs. There's not one bit of evidence to show that's true. None. But that's the common sense that many white folks who voted for Trump have. But maintaining that there're elements of good sense and bad sense in a tense relationship with each other involves me in trying to think about ideology as fractured, as having possibilities, that can interrupt dominance, and that there are partial interruptions already.

Thus, I don't want to demonise common sense. I think that common sense is a place in which conflict goes on. The Right works at deconstructing a more liberal common sense. Think of my metaphor of the umbrella and rain in society. They're saying it's raining, so come over here. Immigrants are stealing your jobs and that the cause of your problems; Black people and poor people are getting something for nothing. And increasingly, they are making these arguments by drawing upon the language of fairness and justice that they steal from Black movements – and I quote: 'White people are the new oppressed'. That's Trump's supporters. The fact that the Right can take progressive language and employ it to move people politically to come under their umbrella shows that populist understandings of the rights of ordinary people have contradictory possibilities. They can be mobilised to lead to genuinely emancipatory movements around fully participatory thick democracy or they can be used to create support for even more repressive movements and policies. So I'm going to say: wait a minute, common sense is a site of struggle. It's not natural that the elements of bad sense dominate over the elements of good sense. That requires hard and creative ideological work to accomplish this. Everybody has some good sense about their lives. And because of that, I believe that it is possible then with hard and creative critical work to pull people from one political

space to another political space. The Right has been able to do that; why can't the Left? But we have to do that. Thus, one of the things I argue is that if you want to understand how to interrupt dominance, look at how common sense works as the site of struggle with elements that are good and bad and then study what the Right has done. They are very good at doing this – as we just saw in Austria or in Serbia or in Hungary or in Poland or right now in the United States. Certainly, my aim is to develop counter-hegemonic work which would interrupt dominance and to pull people away from the umbrella of conservative modernisation. In many ways, this is a critical pedagogic project. I'm not shy. I think there's work to be done not just in schools but elsewhere about convincing people to come this way not that way, to recognise that there are other umbrellas that provide real answers to real problems caused by that rain. In saying this, I am worried about whether this necessarily implies that I want myself and my allies to be hegemonic. I have enough faith in some post-structural arguments that there is a danger in a search for certainty that that can lead to damaging kinds of things. It can lead to the reintroduction of the Bolshevik solution which is based on a position that I want everyone to agree with me. If you don't agree with me, you're wrong – There's a very long and unfortunate history of this on the Left as you know from personal experience here. This is a form of masculinity as well. Honestly, I want us to be hegemonic, sort of. But by that I mean something like what has been built in Porto Alegre in Brazil where the state is a learner as well as a teacher and is strongly connected to a fully participatory set of structures that are constantly being reflected upon publicly and where decisions are based on a process of participatory budgeting and similar mechanisms. This is a very different vision of leadership and of creating a more critically democratic umbrella than the Right's authoritarian forms of 'fake' populism. Thus, I don't want to act like the Right. And I don't want to act like I'm always correct.

So, it seems to me that, yes, we must act and generate consent: that's the hegemonic process but, at the same time, this is an *ongoing* process. If it looks like I am now certain we have gotten there, then I think I am acting in a non-democratic way. I think critical democracy is an ongoing project with no end in sight. Because of that I want to say: yes, we want to be counter-hegemonic and then fully reflexively and self-critically hegemonic, we want people to be much more critically democratic. But words like democracy and criticism change over time as new social movements and the demands they rightly make challenge the oppressive conditions that they face. I want myself and everyone who arrogates the position to themselves as a critical teacher and a critical pedagogue to remember that teaching goes two ways. And if I'm not able to

be criticised by saying 'Michael that's nice, but who gave you power now?', we should not act like the maître d' in this restaurant. It's not up to me to say: you sit here, you sit here, you sit here and there can never be another maître d'.

I think that in some of the postmodern and post-structural criticisms – but certainly this is not true of all of this scholarship – of any substantive exercise of leadership they have taken postmodern criticism of the power/knowledge nexus too far. Such postmodern criticism can be paralysing and the last thing we need is to be paralysed, to be filled with such a strong deconstructivist orientation that we are afraid to act because no matter what we do we are ultimately reproducing various forms of power. Yet within that very same literature is a profound understanding that power can be productive in more democratic ways as well. This is important to me. To me, democracy is a never-ending project. And if it ends with everybody agreeing with me that is really dangerous. So, I must put in mechanisms that guarantee or come close to guaranteeing that I and people like me can be criticised as well because otherwise this process stops. If it stopped decades ago, issues of sexuality would not be on the agenda.

I want to historicise this. What is necessary as new social formations and new forms of identity come up? I don't necessarily always agree with all of them and I'll argue about them. But at the same time these movements become my teachers about what kind of society and education is needed to keep the vast river of critical democracy flowing. To me what is common in any constructive counter-hegemonic project is the worry that we're forming a common without ongoing voices and interruptions. And I want those voices and interruptions to be ongoing. That's my vision of what it means to be critical and my vision of what it means to be democratic. I don't want that hardened and reified. The danger is that the Right understands how to deal with this as well, as it takes the language we use to justify our actions – such as 'democracy' – and largely successfully works to change its meaning from full collective participation to simply individualised consumption practices. Unless we put in place certain things, the Right will colonise that space as well. Given a commitment to democracy as a never-ending process, it's uncertain, you don't know what the end is. People are uncomfortable with uncertainty.

The Right is really good at reoccupying that space. I'll give one example of that in curriculum. When I wrote *Ideology and Curriculum*, I was brought in by activists to work with a group of oppressed Latinos and African Americans in a school system in Texas, and there are a number of very poor parts of the city. The oppressed communities correctly wanted accountability. In their attempt to get that they said: we want teachers only to teach what's in the textbooks. We do not trust teachers. Most of the teachers are white; they don't understand our

culture, and our kids are not doing well. But we can read the textbooks ourselves and know what is being taught. Then we can criticise what is being taught. But when the teachers shut the door to their classrooms, we don't know what they're doing. So, they wanted strict accountability and they wanted schools to show that they were teaching the curriculum that the communities approved. The schools responded by putting in place a standardised official textbook curriculum that limited teachers to teaching only what was in the books and that was based on strict test-based measurements of success or failure. So, the communities and educational activists thought they had won a significant victory. However, that supposed victory was soon turned into a loss as it was used to support an even closer linkage between teaching, an unresponsive standardised textbook-based and test-based curriculum, and ultimately more measurement of students, with the teaching having no real autonomy to actually build an environment and a curriculum that was responsive to students' and community's cultures and histories. The ultimate effect was that the poor kids of colour got labelled as even less intellectually able, as more and more testing was put in place. The victory got turned into a defeat. That's a lesson I want to take very seriously at the level of educational politics and practices.

Janez Krek: *We have to give room for questions. You have definitely raised a lot of possible questions. Does someone from the audience have a question?*

Student (Živa): *I have two questions. My name is Živa, I'm a student here. The first one may be a bit silly but – there's no silly questions, just silly answers – I know, I know, but I can't get it out of my head when you were talking about terms pedagogy and education, I couldn't help but to translate our faculty – we call it faculty of education in English but in Slovene you would translate to 'Faculty of Pedagogy' or 'Pedagogy Faculty'. Why is that?*

Janez Krek: *Well, actually this is not a question for Michael…*

Student (Živa): *I know, but is it a cultural thing, why do we translate it in English, because there's a word 'pedagoška' (pedagogy), so why aren't we using the word 'pedagogy'?*

Janez Krek: *Well, we could go into this briefly. I'm not old enough to know exactly why it was translated like that. Probably Pavel (Zgaga) might know.*

Pavel Zgaga: *In British English, I think even more than in American English,*

pedagogy is more the practice –that would be the methods- pedagogy is being in class and teaching and working with kids and so on. While in Slovenian context 'pedagogika' is related to a German term 'Pädagogik'. This word was used in the past by one of the philosophers, it was Immanuel Kant, you know probably his essay Über Pädagogik that has been translated into English as On Education. And with him 'pädagogik' is still understood in that way as in British English today. So, it is doing it. For example, here, on this side, we are philosophers, some anthropologists, some historians and so on and there, THEY are teachers. 'You' do 'Pädagogik', that is, 'you' are practitioners, but 'we' are philosophers and will tell what the truth is, what the background is, the roots. Later, in German context (which for known reasons strongly also influenced the Slovenian terminological tradition) 'Pädagogik 'was understood as 'Erziehungswissenschaft', the science of education. This dichotomy has been strongly present in Slovenian 'pedagogika' and this was, maybe, the main reason why we were careful using this word, not to send the wrong signal. This faculty was renamed in 1991 from 'Pedagoška akademija', i.e., the 'Teacher Academy', to what it is now: 'the Faculty of Education' in English. In that period, initial teacher education changed from a two-year degree (what you call in American context an associate degree) to university (Bachelor) degree. Being 'upgraded' from a teacher training college (if using English) to a university faculty, the name had to relate to sciences of education. This was the main reason that there was such a trouble about renaming and to find a good name. For translation, we also looked around the world, to other universities, what kind of name they use in English and we figured out that this is 90 % 'Faculty of Education' or similar. So, this is what somebody who remembers the late '80s can tell you.

Michael W. Apple: These are epistemological wars, so the names actually make a difference. We have a building that is next to where my office is at the University of Wisconsin called the Educational Sciences building. The word science in English has a particular sort of positivist meaning, while the general meaning of that concept in Europe refers to particular forms of rationality. Thus it's a much broader concept. In the United States it largely refers to numbers and to a limited sense of 'evidence'.

You asked me earlier on about critical pedagogical studies. I have purposely used the word 'studies', because it doesn't exclude narratives, it doesn't exclude history or philosophy, it doesn't exclude action research and its complexities and contradictions. Just as importantly, it doesn't exclude critical reflections on the world. So, in English, when we hear the words 'faculty of educational sciences', we say: what the hell is that? You're limiting us to these

things that are just empirical in the narrowest sense. These are very different meanings. In this regional area, even with the criticisms made by people such as Habermas, 'sciences' is still a very broad term, but not in the United States. When I say critical educational studies, it's also an interruption, it's not just about pedagogy vs education it's also a reflection on a larger issue. It implies a claim that I and others are making. It's a way of saying: don't call me a scientist, because I'm not certain what you mean by it. You don't seem to mean ethnography and anthropological studies, and you don't mean history or philosophy. What you mean is testing and control groups and medical model research and only 'evidence-based practices' with an extremely limited view of what can count as evidence. These are political and ethical issues.

Student (Živa): *Thank you. My second question is directed more to you I guess. It is about of the future of education in the US with your new president Donald Trump [Apple: You just hurt me badly] I'm so sorry. I guess during campaign we've already seen from the media a change in the society and with the new ministry of education that wants to put more money to the private schools and take the money out of the public schools, where do you see the US education system going, what path is it walking on and where is it leading?*

Michael W. Apple: This is hard to predict. One of the things about Trump and his minions is that you can't predict what they will do next. But I think the tendencies are clear. We have a very small fraction of schools that are private. It's one of the smallest in the advanced industrial nations. And we have the smallest body of religious schools in most nations. In terms of school finance and the kinds of schools we have, there will be many more schools that are marketised, many things called charter schools, which are supposedly under state control but can be basically run by car dealerships or religious affiliations, mega churches. We'll have much more of that. There will be defunding. That has already started in the public sector. I'll give one example: the University of Wisconsin. When I first went there, the state paid 70 per cent of its cost; now it's down to 13 going down to 11 per cent next year. Trump is a true neo-liberal here. Any funding of the state, except if he and his corporate allies have economic benefit from it, will be cut. We'll see the destruction of many faculties and universities and that money being transferred to for-profit universities, to the corporate sector. We will see many more for-profit schools. We'll also see the destruction of teacher unions. That's occurring already. I've just written a study on the Koch brothers who are the third richest people in the United States; they're petro-billionaires, and they have decided now that they and their allies

have won the national election they will put money into the local, on the state and on the national level to guarantee that Rightist control extends to all levels of society, including the local level. They're going to spend millions of dollars on school board elections, people who make decisions about curriculum, about local taxes.

They have just won in one of the strongest union areas of my own state. We will see increasingly the loss of teacher unions. In my own state, the teacher union now has 40 per cent fewer people than it did three years ago. New legislation passed by the neoliberal and neoconservative state legislature has made it the law that unions now dissolve at the end of each year. There're no permanent unions. If you're a public service worker in a union, on December 31st your union dissolves. You must have a new election each year in which 50% plus one person of all members must vote to keep the union alive. If somebody's sick and they can't vote it doesn't count. If people don't vote, their vote counts as a no. Fifty per cent plus one person of all members must vote that the union is reconstituted. But you can't bargain, you can't get raises for instance more than the rate of inflation even if your salary's been historically low and this is occurring at the universities as well. We didn't have a raise for eight years. We will see more de-funding, more de-unionisation and we'll see major changes in the curriculum. The people who backed Trump are very, very conservative, not just neoliberals, but neoconservative and ultra-conservative religious advocates as well.

They will benefit neoliberals because Trump wants more testing and, oddly enough, more control. That means our real ministry of education will be Pearson and other for-profit corporate publishing and media companies. Pearson, for example, is a large multi-billion-dollar test preparation and textbook publisher. In the process, teachers will lose the right to form the curriculum; the curriculum will increasingly simply be purchased. That means that even though teachers will definitely need more nuanced and complex skills of curriculum building that are required for an increasingly diverse society, and where the textbooks can't respond to the many kinds of languages and cultures that teachers will face in schools, teachers will increasingly say: we don't have time to do that. And already teachers are tense and frightened because of the political pressures and the neoliberal and, neoconservative, authoritarian populist, and managerial demands constantly being placed on them. When I speak to teachers, they say 'I can't do that, I'm always looking over my shoulder.'

One of the major reasons for this situation is that we have performance pay for teachers now. If you are to get any federal money, much of your money is based on the test scores of your children in the classroom. There's already

pressure on teachers not to teach creatively but to focus only on these low-level tests. And since we test only in two subjects: mathematics and reading skills, not appreciation, not critical literacy, but only on a very limited set of words and skills, that means that increasingly teachers, especially if you're in poor schools, will have no time and will forget their own skills of building curriculum and building culturally responsive assessments, that make a difference in kids' lives. Instead, the only evidence that will be important will be the standardised tests that are often developed by and purchased from the same large corporations that now dominate curriculum and textbook markets. The result will ultimately be greater gaps in achievement by class and a more racially based achievement gap. At the same time, you have teachers too frightened to do anything about it. And no collective group that they can turn to. You'll see it as well in the process of teacher's certification. Right now, those people here who are in teacher education programmes at colleges and universities get a license that once they complete their intensive study of education enables them to teach. They get an official government document that says you're prepared as a teacher. And for many teachers in Slovenia you need a master's degree, a five-year programme. We too used to be five years. The Republicans and the legislators who are on the Right have said it's too long to become a teacher. Anybody can be a teacher. So let's have this commercialised. Let's turn over teacher's education to Pearson and other commercial companies and for-profit universities so that teacher education is placed on a competitive market with little regulation and no guarantee of quality. The idea of making a profit out of teacher education is also visible in the fact that now to be licensed most future teachers have to take a national test in content and teaching style and methods that is controlled and built by Pearson. And the cost of this for the future teacher is nine hundred dollars a year to obtain the material and to take the test. This makes it even harder for poor and working-class students – and for students of colour – to become teachers.

It is important to see how this produces very negative effects. Many poor students cannot afford to take a test since public universities are already very expensive. To go to Wisconsin to become a teacher, in my own school, is about 20,000 dollars a year, if you're from the state, meaning if you live in Wisconsin. If you live out of Wisconsin, it's 40-45,000 thousand dollars a year. This also has extremely negative effects on who becomes a teacher in other ways. Right now, because university fees are constantly rising, and because Trump and his allies at the national and state levels have made major cuts in the public-sector budget, we have almost no people of colour in the primary teacher education programme even when 50% of the students in our primary and secondary

schools are students of colour. That means that the people who have much more money and who come from more affluent families and who largely come from dominant cultural, economic, and ethnic groups can much more easily become teachers. Yet, many of them have very little experience living in the cities or in slums, and they tend to have very little experience with children who have different languages and cultures.

All of these things will have major effects over time. With Trump as president, he has also brought in with him some other dangerous people. He and his followers in many ministries in addition to education are strong supporters of virulent anti-immigrant positions. They are often committed to what we call popular eugenics, the racist belief that poor people, people of colour, and immigrants are genetically inferior, are violent, and are not deserving of public support. For many of these Trump supporters, white women should have more births. For them, the problem is that Black and brown people are too proliferative, that they have too many children. With this will come many other hidden things. These supporters don't believe in any form of birth control officially. They don't want women to have control over their bodies. And a number of the government officials appointed by Trump want to outlaw and jail women who have had abortions. Thus it should be evident that there're many other kinds of policies that aren't related to education officially, but will have damaging effects on the lives of young women outside of schools.

Inside of schools, Trump and his appointments to lead the Department of Education and other departments in the government at all levels are engaged in dismantling many important programmes that have been victories for women's movements and real women's lives. For example, throughout the United States, programmes have been built in secondary schools for teenage young women who have gotten pregnant, but they can stay in school. Thus, their lives and futures are not ruined. They can bring the baby with them. These programmes actually cut across class lines at times. Yet, these are being defunded and removed, as are programmes in sexuality education, in respect for gay, lesbian, and other marginalised students. The lives of women and marginalised students will be remarkably different inside and outside of education.

All of these policies are creating a disaster. When you destroy unions, it means teachers will not have a collective voice to speak back. And if you demonise immigrant and Black and brown communities as lazy, that they don't work hard and are undeserving – which is also a part of Trump's and the conservatives' underlying rhetoric – this too creates a situation where large portions of the American population begins to share these perceptions of 'the Others' as 'immoral', and not worthy of respect. This is exactly what is happening.

The situation is made even worse by the press and other media where Trump's voice is heard daily, and the voices of criticism and dissent will either be absent or will have to struggle to be heard. Thank you for a very interesting question, I am personally very worried right now. However, there are also very real reasons for hope. In my newest book, *The Struggle for Democracy in Education*, I describe a number of significant things that are happening in education that signify victories not only defeats.

Rima Apple: *You were talking about people who are going to teach different cultures, they will not stay very long because when they walk into the classroom, it is such a cultural shock to them, they last only two or three years. So, children are also hurt because they are constantly getting inexperienced teachers. And we're seeing that already in Wisconsin where the number of teachers who are resigning at the age of 25 or 28 is just astronomical.*

Michael W. Apple: You can see these trends that Rima is talking about in teacher education. There's something that I don't think it exists here called Teach for America. It's now international. There's also Teach for Chile, Teach for Argentina, Teach for China, Teach First in England, and similar things in many nations. It is based on the belief that state-supported teacher education is a failure. It says let's take it out of universities, there's no reason for university teacher education and, in fact, let us close colleges and departments of teacher education. And close entire faculties of education. That's over-all their agenda. Some of these programmes are officially not-for-profit; however, many of these private programmes are profit driven. In most of these programmes, your only preparation to become a teacher is a summer of teacher education, six weeks, and then you're placed in the most difficult classrooms in rural and usually urban areas. The hidden assumption underpinning the positions of some of their supporters is that you don't need much education in education itself to be a teacher. I quote from them: 'Anyone can teach'. In many places, if you have a university degree, you can get certified with no serious preparation at all. Just as importantly, you are given almost no background in foundational subjects such as the history, sociology, and philosophy of education. All you get are 'practical' subjects, and only six weeks of that. You then sign a contract that says that you will work in that school for two years. Many of the people will work in the schools for two years and then they go to law school or medical school or to work in the corporate sector, because it looks good on their resume. It's like a conversion strategy. And less than 40% of the people in Teach for America stay in teaching. Rima's point is actually very important. It takes teachers time

to mature and it takes years to develop who you are and the complex skills and values and knowledge that are required to be an excellent and responsive teacher. The assumption that you don't need history or sociology or philosophy goes with the disrespect that these programmes show to the complexities of doing substantive work in real schools. Why would you need anything that raises questions? Or learn about serious critical research? Or learn how to engage in researching education? The implications for PhD students in education are massive as well. Why would we need that in education, since part of our agenda is to close schools of education? This will mean the tragic loss of the important traditions of asking critical questions about the means and ends of education, about its role in society, about ethics, about all of the things that make education so much more than merely training. And you can hear it in the questions that future teachers increasingly think are the most important – and sometimes the only – questions to ask. How do I control these children? Give me more management skills. Why am I learning philosophy or sociology or history or psychology or psychoanalysis or any of these kinds of things that are foundational? Why would I need this? It is the destruction of intellectual life and I predict much more unemployment for people with PhDs in human sciences and in education. That is truly destructive because that leads to the loss of memory. Once it's gone, it's almost impossible to replace. In the process, some of the most important questions about education no longer are even asked.

Darko Štrajn: *What were you implying by referring to culture? I would say from Walter Benjamin on we have to speak of culture as a mass culture. There is, of course, this elite culture that Bourdieu talks about in his La Distinction. But, actually, the culture that I think that concerns teachers, schools, is mass culture. Recently – I mean in last two or three decades – this culture is being overflown by new media. And there is a lot of discussion of so-called new literacies. As one can see this, it is some sort of media illiteracy that probably helped the new Right to gain such a big social space. I know that you think about it. What is your idea about these so-called new literacies?*

Michael W. Apple: We have been through this before many times. Nothing we are facing in the United States is any more difficult from the fact that the US was basically South Africa with an apartheid system during my lifetime. If you look at a teacher's contract from 1923, that was standard in the United States, women teachers were paid $75 a month, and men teachers were paid $225 a month. Women's underwear was policed. The contract said you must wear two undergarments and it was the task of the principle to check on women's

underwear. This seems bizarre but that was the daily life of teachers. And we were a system based on racial divisions. Nothing we are facing is harder than that. I come from a family where family books in the 1950s – starting with what was called the Red Scare in the United States – were buried under the barns in my grandfather's chicken farm because we were so frightened that we would be arrested. Now those things come back, and the fact is that this is not a pendulum that is automatic, but we have been through this before.

And somehow, there have been constant mobilisations against these things. That's why I like the term from Raymond Williams of the Long Revolution. It took 20 to 30 years for the Right to make me feel really depressed… 20 or 30 years of hard work. There is an old saying that says it's 20 miles into the forest, it's 20 miles to get outside the forest. I am deeply committed to saying we have been through this before.

The latest book is a response exactly to your question about pessimism which is: can education change society? This book is meant as the first of the series of three volumes. It says: this is what we must do. What can we learn from the people for instance within Black and brown communities that faced murder and still do? You undoubtedly heard a decent amount of the news of young black men being shot in the United States. That's nothing new. But it is the case that we have had this before and the fact is that it will probably happen again, but we need to have the leadership from the people who have successfully countered this. And that means we must learn from places like Brazil, we talked a little bit about that, and other places that have faced this and countered it. And constantly do.

Can Education Change Society is part of my response. What are our tasks, what do we learn from previous iterations? Let's not romanticise it, and think this will be easy. But I am ultimately optimistic about that. In part, because I think of my own understanding of mass culture, by the way, which is a space of interruption as well as a space of commodification.

I think that the new literacy has become very interesting because I think they are forms of interruption and they are constantly being attempted to be commodified. So, let's take hip-hop. It starts as speaking back to dominance and is created from voices from the Black communities and even the way of dressing was a way of speaking back. So, if you've ever seen hip-hop, for young Black men pants in particular are often down to here, down well below the waist Welcome to my underwear! Do you know the history of how that started?

Since one in every four African American men in many parts of the United States were in prison and they were not allowed to have belts, the pants fell down to here and the hips kept them up. Young Black men in schools said

consciously: we will show solidarity, we will not wear belts. Our pants will go down because we must show that we understand what this society is like.

Now you can buy pants that are really wide over here and it's three hundred dollars; you can buy hip-hop pants. That contradiction, that constant struggle over what mass culture commodifies, what it makes for sale, the anti-oppressive bodily forms and musical forms that go with hip-hop music and gangsta rap carry these contradictory meanings and processes. The widest audience for gangsta rap, with its tendencies to call women 'hos' (whores) and things like that is white suburban affluent boys. What? That's very interesting. It is used by white suburban boys against this vision that they're supposedly well-mannered nice young men who accept the dominant norms of society. They're listening to hip hop and gangsta rap and their styles of dress embody complicated and contradictory appropriations of mass culture. They use it as well as a form of opposition to age oppression. We need to remember that there are complex processes of re-appropriation at work here.

This doesn't mean that I like it. In many ways, I think its re-appropriation by affluent white youth is a form in which we colonise the space of Black youth. Thus, at times I find it a very bad idea. I find it deeply offensive. But on the other hand, 'message sent is not always message received'. So, following after Benjamin and Adorno, there have been additional gains in our understanding of mass culture and lived culture. Although I am not in total agreement with all of his arguments which at times seem rather overstated to me, I certainly respect Benjamin. His work is very powerful even today, in large part because he opened that space for that conversation. But I would prefer to look to people like Stuart Hall and the next generation who have talked about that and to say these things are constantly in motion, there's a constant dialectic, of insurgent popular forms that then are colonised and occupied and commodified by powerful agents and processes, and then disarticulated from commodities and used in different ways again. And it's a constant process. Let's take hip-hop. It is now bought and sold for money and simultaneously used by various groups as a way of speaking back to power.

On the other hand, I know people in education who are very Gramscian around mathematics and science, who are saying we are not doing Black and other minoritised kids who are poor any favours if we don't teach them things that are on the test or are part of the dominant culture. Because we're guaranteeing they will be failures. So, in many cities in the United States curricula in science that draw upon hip-hop have been developed. They are often quite socially critical. That's really interesting. There's a danger here in appropriating what started out as a counter-hegemonic cultural form into school knowledge

of course, because it makes hip-hop safe and anything that's counter-hegemonic and gets into schools can be used as a way of only saying: well let me show you how poetry works using hip-hop, thereby eliminating its resistant history and meanings. Richard Johnson has a very significant essay called *What Are Cultural Studies Anyway*? He says there's a circle of cultural production that has three moments that you can interrupt. One is the moment of production: who produces it under what conditions? You can interrupt there. Right now, it's often rich (and often) white men controlling music companies, taking hip-hop and gangsta rap and producing it for profit. But there are now insurgent movements among Black street artists using new technologies to produce themselves and to make it available on the web, so it keeps its vision of 'we are not for sale for white profit'. The second moment is the process of distribution, the moment of distribution, may now be produced by insurgent voices. It is distributed through new technologies that have voluntary payment. It's crowd-sourcing in some ways. That's really interesting. That takes out the middle person and has a different relationship between the commodity and the audience. And there is a third moment, the moment of reception or consumption. This involves the way in which cultural form and content are actually used by people and interpreted in different ways. Stuart Hall and Paul du Gay have a book *The Story of the Sony Walkman* – because no women were alive in Japan at that time I guess? (sorry for the joke) – but in which they show how this kind of process works even with the Sony Walkman. It was commodified but then you put it in your ear and can listen to revolutionary material and feminist and anti-racist music as well as mass cultural forms produced for profit and then you interpret it. This circle can be interrupted at multiple moments and is a source of freedom. The commodity also carries with it sources of possible resistance. That, by the way, is Foucault in some ways.

I think that this idea that all these kids are media illiterates is not necessarily the case or at least is overstated. But even if it is true, there're efforts to combat it as well that're being done for example in Belgrade as well by Dejan Ilic and Ana Kolaric on media literacy that can provide a model actually in this region of having youth look at films, look at media, look at commercials and deconstruct the dominant meanings. It's not easy or natural at this moment of reception of reading stuff in non-dominant ways. That's a space for pedagogic work. There are programmes in critical media literacy all over the world now that need to be put in conversation with each other. And Allan Luke's work on media literacy, what is called the new media literacy, has now become more influential. I think that these tendencies and approaches are very interesting. There's also a centre for computer game research at my own university where

the idea is if you want kids, including poor kids, to be critically literate, look at all the literacy work they're doing on gaming and other forms that we usually do not associate with literacy work. Another example of these kinds of things is popular fantasy games where girls are using that medium to make their own games where women have more powerful roles, ones that do not include violence against women's bodies.

So, there're really interesting actions that are going on, and I have some faith in that. I think that insurgent cultural formation is going on all the time, and one of the things I want to do in the new book is to point out where that is happening. This is the next agenda after all this deconstruction. Remember, when I said at the very beginning: I have two issues. How do we understand how power works for the production of dominance and subordination and how do you understand how to interrupt it? The next books, such as *The Struggle for Democracy in Education* that has just been published, will be on the limits and possibilities of that.

Janez Krek: *Dear professor Michael Apple, thank you for your answers and for being with us at the Faculty of Education University of Ljubljana.*[2]

2 The interview has been authorised by M. W. Apple in January 2018.

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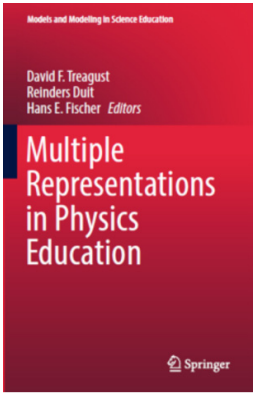
David F. Treagust, Reinders Duit and Hans E. Fischer (Eds), Multiple Representations in Physics Education, Models and Modelling in Science Education (Volume 10), Cham: Springer, 2017; 322 pp.: ISBN 978-3-319-58912-1

Reviewed by Neja Benedetič[1]



Teaching is a mission in which we strive to demonstrate new concepts in many ways, so that pupils and students acquire new information and are enable to construct entirely new concepts. This is only possible with the prudent use of multiple representation. Most teachers do not teach only verbally; they also use a lot of models, pictures, diagrams and analogies. However, in using multiple representation, we have to be careful not to add, change or omit information that influences the understanding of the new concept. Teaching physics and natural sciences is no exception. Using different types of representation (pictures, experiments, photos, films, sketches, etc.) enables teachers to catch all of the important events that could be missed without representations. We then start to analyse the events in many ways (diagrams, graphs, formulas) in order to obtain complete information and make it easier to understand.

The book *Multiple Representation in Physics Education* deals with multiple representation and the doubts that we may have about its correct use. The book is divided into three parts, with the introductions to the individual parts being written by the editors David F. Treagust, Reinders Duit and Hans E. Fischer. David F. Treagust has the title of John Curtin Distinguished Professor at Curtin University in Perth, which is the university's highest honour. Reinders Duit is a Professor Emeritus for Physics Education at the National Centre for Science Education Research at the Institute for Science and Mathematics Education in Kiel, and Hans E. Fischer is a Professor Emeritus at the University of Duisburg-Essen in Essen.

The first chapter is an introduction to the book, with the authors (Maria Opfermann, Annett Schmeck and Hans E. Fischer) clarifying the concept

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of multiple representation according to different theories (CTML – Cognitive Theory of Multimedia Learning, ITPC - Integrated Model of Text and Picture Comprehension, and DeFT – Design, Function, Tasks). They conclude that multiple representation does not overload a single channel of information (as is the case if we use only one type of representation); instead, the complementary information that we acquire with multiple representation enables us to construct and reconstruct the new concept. This is the only way to avoid misunderstanding of a new topic.

The book is then divided into three parts. The first part contains three chapters focused on models and analogies. In the second chapter, Per Morten Kind, Carl Angell and Øystein Guttersrud present the project PHYS21, which was performed in a physics course for upper secondary students in Norway. The aim was to develop teaching materials and strategies to teach physics and to observe the effects of these new materials in the classroom. The project had three sections: the first was about what happened in classroom, in the second the focus was on teachers' conceptions of teaching and the curriculum, and the last part was about the effects on student learning. Analysis was undertaken using interviews with teachers, as well as a comparison of data from student questionnaires in experimental and control groups. The authors conclude that teachers need more support to achieve an adequate level of multiple representation; the researchers will therefore attempt to develop specific activities in this regard.

In the third chapter, Brian E. Gravel and Michelle H. Wilkerson write about the integration of computational artefacts into a multi-representational toolkit for physics education. They present two cases in which they use computational artefacts to understand new content (in the first section, the behaviour of liquid crystal, and, in the second, the formation of a cloud) and introduce three discursive moves used in making the computational artefacts.

In last chapter of first part, Jing-Wen Lin and Mei-Hung Chiu reflect on how to design multiple analogies to achieve better effects than a single analogy, but without additional cognitive load. Their research focuses on an electric circuit system and its analogies as simple water circulation, complex water circulation and an obstacle race. The authors found that students preferred analogies that were familiar to them. They concluded that there was positive feedback about the use of multiple analogies and that they could play a powerful role in knowledge construction in learning science. There is a large gap between students' prior knowledge and new concepts, and multiple analogies can be used to bridge this gap.

The second part of the book contains four chapters in which the authors present different approaches to and conditions of multiple representation.

In this part, it is shown that multiple representation has an important role in physics, as it presents different levels of abstraction, enabling abstraction to be linked to the functional rules of constructing and predicting effects, and to the development of physics concepts.

In chapter five, John Airey and Cedric Linder derive multiple representation in physics from a social semiotic approach (examples of the semiotic resources used are graphs, diagrams, mathematics, specialist language, etc.). They suggest that teachers need to enable their students to use multiple representation, so that they can achieve fluency in its use and create critical constellations of given concepts. Students must be aware that, in order to achieve fluency and critical thinking, they have to use multiple representation as much as possible (process of repetition).

In chapter six, Yen-Ruey Kuo, Mihye Won, Marjan Zadnik, Salim Siddiqui and David F. Treagust present multiple representation used in learning optics. The authors investigate students' use of multiple representation in a first year physics course for non-major students over two years at a university in Australia. They found that correct use of multiple representation increased during the investigation. When students are able to use multiple representations, it is easier for them to integrate different representations and to understand new concepts.

In the next chapter, the authors (Peter Hubber and Russell Tytler) explain guided inquiry as an intermediate teaching approach between open-ended, student-directed learning and traditional, direct instruction. The aim of their study was to document the experience of four secondary teachers in implementing a representation construction approach, and to investigate the quality of student learning of astronomy. They discovered the importance of the use multiple representation (sketches, illustrations, text, mathematical formulas, graphs, etc.) in conjunction with classroom discourse to understand certain astronomical phenomena.

In the eighth chapter, Pasi Nieminen, Antti Savinainen, and Jouni Viiri studied the concept of force among 16-year-old students taking only one physics course. They found that an interaction diagram is a suitable learning tool and should be used systematically in teaching. Furthermore, they are convinced that multiple representation should be used appropriately not only in the classroom, but also in textbooks and homework.

In chapter nine, Chee Leong Wong and Hye-Eun Chu focus on representations of electric current in textbooks. They warn teachers to be wary of inconsistent representations in textbooks, which can result in students misunderstanding some concepts. The authors also point out that, despite the best efforts of the teacher, students may not always understand multiple representation.

In the third part of the book, the authors of all four chapters focus on reasoning and representational competence, which students need in order to use and apply different representations. In addition, students have to use their abilities to explain and assimilate the representations appropriately.

In the tenth chapter, authors Andreas Müller, Rosa Hettmannsperger, Jochen Scheid and Wolfgang Schnotz introduce representational coherence ability and representation-related conceptual change in geometric optics. Their investigation was performed in German schools and they chose experiments in geometrical optics due to their ability to incorporate the use of multiple representations. They conclude that students have to acquire the ability to achieve representational coherence (i.e., correct and fluent combination of multiple representation is essential for proper understanding of an experiment) and then to link scientific experiments and their conceptual bases with different multiple representations with various levels of abstraction (realistic drawing, diagrams, graphs, text, mathematical relations, etc.).

Chapter eleven is written by Patrick B. Kohl and Noah Finkelstein, whose aim was to understand and promote the effective use of representation in physics learning. They investigate the assumption that if students answer a question in one form they will also be able to answer it in other forms. Their research showed that the representational form of the question and the teaching environment influence students' performance and their ability to reason across representations. The authors' findings also suggest that it is sensible to develop representational competence in a content-bound manner, and it is fruitful to provide opportunities for students to practise the use of coordinated representation.

In chapter twelve, Jennifer Yeo and John K. Gilbert focus on the role of representation in students' explanations of four phenomena in physics: dynamics, thermal physics, electromagnetic induction and superposition. They investigate what type of representation is most commonly used by students to explain each of these four physics phenomena. The authors examine the students in three dimensions: function (to provide an answer to specific types of question), form (structural organisation) and level (precision, abstractness and complexity). The authors found that students use an interpretive explanation of dynamics and thermal physics (descriptive and quantitative style of reasoning) and a casual explanation of electromagnetic induction and superposition (narrative and qualitative style of reasoning).

The last chapter of the book was written by Florence R. Sullivan, W. Richards Adrion, Dave Hart, Christopher N. Hill, Kofi Charu Nat Turner, Jeff Xavier, Youngkwan Cha, Sangchil Lee and Bradford Wheeler, and is focused

on learning about global heat transfer using multiple visualisation in an online learning environment. The authors claim that if students are supported to understand representation in two- or three-dimensional scales, they understand the overall concept better. In addition, they observed that 3D videos lead to more sophisticated responses by students, while 2D representations are more focused on physical descriptions.

The book *Multiple Representation in Physics Education* offers a comprehensive overview of using multiple representation: its positive side, as well as warnings about excessive use or lack of use, and about multiple representation used in textbooks, which is sometimes inappropriate. The studies contained in the book were made on different levels of education and on different physics topics, and therefore provide a good insight into the use of multiple representation. In conclusion, we can say that multiple representation has a significant role in teaching physics. Different representations allow students to introduce concepts from different aspects, combining graphs, text, mathematical formulas, schemes, gestures, etc. into a whole. In physics, we frequently use equations to describe dependence between quantities, but for students it is often a challenge to combine physics equations and modelling tools; for them, equations and physics concepts are two different objects. It is therefore crucial for the teacher to use multiple representation and to enable students to establish correlations between different representations.

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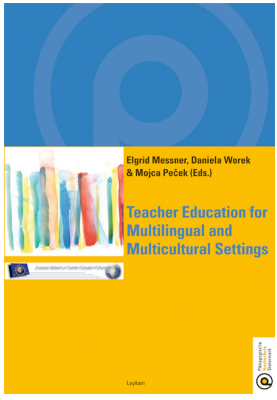
Elgrid Messner, Daniela Worek and Mojca Peček (Eds), Teacher Education for Multilingual and Multicultural Settings, Graz: Leykam, 2016; 199 pp.: ISBN 978-3-7011-0361-4

Reviewed by Karmen Mlinar[1]



The growth of migrations that are changing the face of Europe brings various challenges that society, and particularly educational institutions, are able to confront to varying degrees. Today, it is clearer than ever that existing integration (or segregation) policies are insufficient, and that these policies cannot or do not know how to properly deal with the increasing diversity of society and the diversity/otherness of its new members. The role of educational institutions at all levels is therefore all the more important. It is at these institutions that future generations of individuals are formed and educated, individuals who will have the opportunity to build a society in which everybody is respected and accepted despite and because of their otherness, and where the differences are understood as new values, rather than contributing to a closed society full of fears, prejudice and hate.

The scientific monograph *Teacher Education for Multilingual and Multicultural Settings*, edited by Elgrid Messner, Daniela Worek and Mojca Peček, and published under the auspices of the European Network of Teacher Education Policies, offers the reader critical analyses and answers, but also opens numerous important issues and topical dilemmas related to the multicultural environment we face today. The volume consists of an Introduction, four thematic chapters, and Conclusions and Recommendations.

In the *Introduction*, the editors present the development of the monograph, which began in 2015 when, at the autumn ENTEP conference in Ljubljana, Slovenia, the debate was focused on the dilemma of how to prepare teachers for teaching in diverse settings. In the Introduction, the content of the monograph is briefly presented. The second paper of the Introduction, written by Ursula Uzerli, addresses the need to provide teachers with intercultural

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awareness and competences, including the ability to be self-reflective. As the author emphasises, it is crucial that university programmes, especially in the initial phase of teacher education, prepare teachers for the challenges of culturally diverse classes. The article briefly presents the possibilities that are already offered by some European countries and describes some examples of specific curricula in Initial Teacher Education and Continuous Professional Development for (future) teachers in diverse settings.

Chapter I (Theoretical Considerations and Practical Insights) begins with Robi Kroflič's article setting out the shortcomings of Rawl's concept of distributive justice, and emphasising the need to focus on the recognition and representation of marginalised pupils/students. For the author, one of the most important pedagogical questions in multicultural education is how to change our attitudes towards the other as different. One of the ways to achieve this goal is the inductive educational approach, and one of the tools is education through artistic experience. The author presents some examples of implementing multicultural education with children/students and the importance of the teacher developing a proper attitude towards the otherness of the other. The next article, written by Sonja Rutar, discusses the pathways to achieving quality in education. In the first part, the author explains the meaning and importance of quality in education and distinguishes it from effectiveness. She then explains how to achieve quality through positive recognition, literacy development and child participation. In her article, Nada Turnšek presents the theoretical foundations of three approaches to diversity, equity and social inclusion: the multicultural, the intercultural and the anti-bias approach. The author starts by presenting the development of the concepts, and continues by presenting and critically evaluating the practical applications of each of them in some Slovenian preschool institutions. She points out the importance of the antidiscrimination and diversity training at the Faculty of Education in Ljubljana, as a programme that equips preschool teachers with competences that enable the application of the anti-bias approach. For the author, this approach, unlike the other two approaches, is related not only to activities for children, but also to the creation of a group ethics and ethos, characterised by equality and an anti-racist environment. In their article, Sunčica Macura and Bojana Dimitrijević analyse the position of the inclusive education of Roma children in preservice teacher education programmes in Serbia. Many teacher educators fail to face the topic of social exclusion and therefore contribute to maintaining the status quo in society; on the other hand, as victims of their own stereotypes, they are unable to prepare student teachers to teach and educate in a culturally diverse environment. One of the main reasons for this is the restrictive concept of inclusive

education, which is still generally connected with pupils with special needs and not with pupils who need additional support. The authors then offer an interesting insight into two models of practical activities that prepare teachers for multicultural settings with Roma pupils in Serbia: Intercultural Experiential Learning and Cross-Cultural Field Experience, which prepare and motivate student teachers to work with Roma children. As the authors point out, there is a need to continue to develop models and practices that can prepare teachers for better work in diverse environments. The last article of the first chapter, written by Mihaela-Monica Stîngu, Elena Marin and Georgeta Ion, discusses the question of facing diversity issues in the context of higher education. As the authors stress, in the context of higher education, equity – a key concept in education – means to enable all students to exploit their potential by creating a system that "creates opportunities for equal access and success among all vulnerable students" (p. 76). In the article, the authors analyse the status of equity in higher education in Romania through policy and practice, with a special emphasis on teacher education programmes. The status of intercultural education in such teacher training programmes should change, because, as the authors stress, is not represented enough.

Chapter II (European Perspectives and Initiatives) begins with Francesca Caena's article presenting the multilingual and intercultural agenda in the European context, highlighting European language teacher education. The author presents the Italian context, where non-Italian students need special support in education; to make this possible, however, teachers need support, too, especially related to lifelong learning, which includes reform of the teaching profession. Klaus-Börge Boeckmann begins his article with a presentation of Council of Europe and European Union documents on teaching in a culturally and linguistically diverse context. As the author determines, all of the documents share the common finding that "all teachers/educators in the system need initial, pre-service and in-service training especially designed to enable them to cope with linguistic and cultural diversity" (p. 105). In the second part of the article, the author presents two Austrian application projects: Majority Language Instruction as a basis for Plurilingual Education and the Framework of Reference for Pluralistic Approaches to Languages and Cultures; and an initiative called Autobiography of Intercultural Encounters. Even if there is widespread agreement on the measures that should be taken in relation to multilingualism, multiculturalism and migration in school systems, teachers themselves, and even teacher educators, are not clear about which tools to use in the classroom. The author therefore suggests the development of materials on the European level, which can then be adapted on the local level.

Chapter III (Policy Measures) begins with an article by Vlatka Domović and Vlasta Vizek Vidović. The authors present the Croatian context of multicultural and intercultural education and analyse the policy framework for minority and multicultural and intercultural education by pointing out the problems faced by schools and related to teacher preparation to teach in diverse contexts. The Croatian authors again find that intercultural education in initial teacher training is recognised as important at the policy level, but is not compulsory in curricula. As the authors determine, teachers are not sufficiently prepared and equipped with competences to teach in culturally diverse contexts. The authors therefore stress the importance of the development of intercultural competences during initial teacher education and continuous professional development. In the next article, Larisa Kasumagić Kafedžić presents a brief overview of post-conflict education in Bosnia and Herzegovina, where post-war society is very fragmented, opening the question of whether the education system is capable of taking responsibility for promoting the values of non-discrimination and peace. Despite there being more questions than answers, the author unequivocally addresses the importance of the training and continuing professional development of teachers, oriented to the multicultural and intercultural context. The third article of the chapter, which is the work of Jean-Jacques Weber, treats the case of Luxemburg. The author first presents the complex language situation in Luxemburg – where German is the main language, followed by Luxembourgish and French – and the implications of this for the education system. Given that the home language of the majority of pupils in many primary schools is one of the Romance languages, and due to the historical context of the trilingual system, the question arises as to whether the language-in-education policy should be more open and flexible, which would also have repercussions for teacher education and the establishment of linguistic tolerance as a key value among teachers. The last article in this chapter is written by Dagmar Gilly, Daniela Gronold and Barbara Schrammel-Leber. The authors present the activities and projects of the Austrian Federal Centre for Interculturality, Migration and Multilingualism, which supports the University College of Teacher Education "in the process of opening up to diversity" (p. 146). The Centre has an important role in cooperation and quality development related to interculturality, migration and multiculturalism in teacher education and training in Austria.

Chapter IV (Mobility) begins with an article by Haiko Vogl, Goerg Krammer, Susanne Linhofer and Regina Weitlaner that systematically describes and analyses the University College of Teacher Education Styria's Erasmus+ course "International Teacher Competences". The programme provides students with a variety of learning opportunities that shape their personalities,

resulting in greater employability of prospective teachers. The authors also present a qualitative content analysis of the merits of the course through the Big Five factor domains (openness, emotional stability, conscientiousness, extraversion, agreeableness). The results show that the course not only provides all of the benefits expected in a mobility programme, but also enhances the students' future teaching career. In the second article, Daniela Elsner and Daniela Worek discuss the opportunities for and obstacles to mobility in German Teacher Education Programmes from the point of view of the professionalisation of teachers in the context of diversity. The authors point out the need for the international experience gained by students studying abroad, as well as the benefits of such experience, but note that the quantity and quality of measures taken by universities are very different. It is necessary to give credit for "international activities, transitional education or inward and outward mobility" (p. 175), in order to integrate globally themed activities in teacher education, to include more international students in teacher programmes, etc. As the authors point out, there is therefore a need to rethink the current education system.

In Conclusions and Recommendations, Mojca Peček first analyses the conceptual framework for teacher education and stresses that different countries have different explanations for "cultural diversity", despite the fact that the goal of most countries is to build a society in which all cultures are equally respected and included. She points out that there are differences even in the understanding of teacher competences for managing diversity in the classroom, but that most researchers nonetheless emphasise the importance of the cognitive, pragmatic and affective dimensions of intercultural competences. Next she turns to the organisational aspects of teacher education. Despite the fact that, on the European level, intercultural competences of teachers are recognised as crucial for work in linguistically and culturally heterogeneous classrooms, studies show that the development of these competences at the national level is not always included in teacher education programmes. It is therefore very important, as Mojca Peček explains, that European guidelines are implemented in teaching practice. Finally, the author stresses that the knowledge gained during the study process is not enough to guarantee an inclusive environment and to improve school practice; it is important that future teachers work on themselves, that they confront themselves with their own behaviours and practices. In this regard, in the last part of the volume, the author lists a series of proposals on how to improve teaching programmes for teachers in order to enable successful work in multicultural and multilingual settings.

The volume certainly provides an interesting and systematic insight into European theory and practice related to multicultural and multilingual

settings, and offers a series of proposals on how to improve teacher education programmes. There is a need for student and professional teachers to gain intercultural competences and other abilities on the cognitive and personal level that are essential for work in inclusive environments. Today, it is essential to discuss examples of good practices and to expose incorrect practices; at the same time, there is a need to present suggestions to complement, upgrade or improve such practices. Multiculturalism is no longer a question, nor is it a matter of time; it is a fact that influences and will continue to influence European society. The question is whether this society will be one characterised by intercultural dialogue, coexistence and respect, or a society divided into "us" and "them". The role of education institutions is crucial in facilitating the development of the first option. These institutions will teach pupils how to confront their own fears, prejudices and stereotypes, and how to live in mutual respect and appreciation. To make this possible, it is essential that teachers develop adequate competences and personal qualities to work in an intercultural way. We believe that the present volume is an important source of knowledge and ideas, providing a basis for the further personal development, work and research of student and professional teachers who already work or will work in multicultural and multilingual settings, as well as being an important resource for planners of teacher education programmes.

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