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, two in English and two in Slovenian (with English abstracts). 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.

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. Dve številki sta v angleškem jeziku, dve v slovenskem. Prispevki v slovenskem jeziku imajo angleški povzetek. Številke so tematsko opredeljene, v njih pa je prostor tudi za netematske prispevke in predstavitve ter recenzije novih publikacij.

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Editorial

The thematic focus of the fourth issue of the CEPS Journal is visualisation in education. Thus the main purpose of this issue is the presentation of the use of visualisation elements in different areas of education. The submitted papers were mostly from the field of science education, and the review of the manuscripts resulted in only papers from science education being published.

Visualisation in education relates to a specific way of teaching and learning content in various subject areas (natural sciences, mathematics, social sciences, languages, art) with the aid of specific images. With the assistance of visualisation elements, so-called visual learning takes place. This encompasses a familiarity with systems of symbols within scientific disciplines and the development of an ability to interpret the meaning of a particular concept with the use of these systems, all of which are presented with some kind of representation. The following content areas are presented in the papers published in this issue of the CEPS Journal: (1) visual representation as a tool for: (a) illustrating concepts, (b) problem solving, (c) explaining ideas, (d) assisting individuals' mental models of concepts and their integration into the individuals' already existing mental scheme of the concepts, and (e) identifying and changing misconceptions; and (2) the importance of different ICT visualisation approaches in the process of learning.

Visualisation is used in science education in its broad spectrum, from static physical models and different types of pictures to multimedia animations and interactive simulations of science phenomena. Modern ICT visualisations (animation, simulations and virtual reality) are becoming an increasingly important tool for presenting abstract and complex phenomena that were previously impossible to present to students at different levels of education. These interactive simulations and virtual reality environments can offer students active learning and opportunities to manipulate science phenomena to the level they feel comfortable with while learning science concepts. As Gilbert (2005a) pointed out, the two main roles of visualisation in education are to visually represent science concepts (external visualisation) and the formation of the learners' mental model of the represented concept (internal visualisation). He also stressed that although external visualisation is a more frequent subject of science education research, internal visualisation must also be understood as an important research issue. An important aspect of visualisation in education lies in the fact that textual learning material has a linear structure, and thus offers the least support for developing adequate mental models. Therefore, 2D and 3D visualisation, and especially dynamic representations such as multimedia and interactive simulations supported by modern ICT, offer the learner the greatest support in developing the internal visualisation of science concepts. Visualisation should tell a story in the process of learning. Based on an analysis of science textbook visualisation, Tversky (2005) suggested that two types of visualisations dominate: structure visualisations (diagrams showing the special and conceptual relationship of a specific part of scientific phenomena) and process visualisations (diagrams showing changes in scientific phenomena over time). They also concluded that many representations combine both types in order to show different important aspects of the presented phenomena to the learner.

An important aspect of visualisation that is not well researched in the field of science education is the concept of metavisualisation, which can be interpreted as a part of metacognition (Gilbert, 2005b). It can be suggested that future research should be focused not only on the types of external visualisations that are important for learners' understanding of science concepts, but also on the importance of learners' understanding of their mental model forming. Various research strategies should be used to explore these aspects of presentations in science education, especially strategies focusing on qualitative approaches to determining learners' internal visualisation (Vogrinc & Devetak, 2007). Finally, it is important to emphasise that visualisations are an essential part of teaching, understanding and creating scientific ideas (Tversky, 2005), and as such an important and interesting area of science education research.

In the present issue of the CEPS Journal, four papers from respected authors from different countries, including Turkey, England, Scotland, Australia and USA, discuss visualisation in science education.

The paper by B. Timur and M. F. Tasar entitled *In-Service Science Teachers' Technological Pedagogical Content Knowledge Confidences and Views about Technology-Rich Environments* presents teachers' confidence in technological pedagogical content knowledge and illustrates their views about using technology-rich environments (TRE) in science instruction, which is an important issue. The authors discuss the importance of computers and related information communication technologies in enabling visualisations of various scientific concepts, natural phenomena and mechanisms by creating technology-rich environments (TRE). It is important that teachers are aware that TRE offer them opportunities to visualise science phenomena that might be difficult or impossible to view, dangerous to conduct experiments about, impractical or too expensive to bring into the classroom, or too messy or time consuming to prepare in a school laboratory. However, they note that science teaching cannot and should not be undertaken entirely by TRE, but that it is nonetheless absolutely imperative for science teachers to know how to integrate technology into science classrooms. This paper addresses challenges faced by in-service science teachers when creating TRE and gives suggestions for successful TRE integration into science teaching. Timur and Tasar present results and discuss findings showing that in-service science teachers have a low level of confidence in using TRE during science teaching. Teachers participating in the study, however, stressed their need for professional development activities regarding the effective and meaningful use of TRE in science teaching.

In the second article of the present issue, *Student Engagement with a Science Simulation: Aspects that Matter*, S. Rodrigues and E. Gvozdenko propose guidelines for forming interactive science simulations. The authors try to illustrate the importance of multimedia technology that affords an opportunity to better visualise complex relationships often seen in chemistry, describing the influence of chemistry simulation design facets on user progress through a simulation. Three versions of an acid-base titration simulation were randomly allocated to 36 volunteers to examine their interactions with the simulation. The impact of design alterations on the total number of interactions and their patterns were analysed according to specific factors, namely: (a) the placement of a feature on the screen, (b) the alignment of the sequence of instructions, (c) additional instructions prior to the simulation, and (d) the interactivity of a feature. The authors also present interactions between individual factors, such as age, prior experience with science simulations and computer games, perception of the difficulty of science simulations, and general subject knowledge, on one hand, and the efficiency of using the simulation, on the other hand. The results show that the centrality of the position of an element significantly affects the number of interactions with the element, that re-arranging the sequence of instructions on the screen in a left-to-right order improves the following of instructions, and that providing users with additional written advice to follow numbered instructions does not have a significant impact on student behaviour. The results also indicate that the interactivity of a feature has a strong positive correlation with the number of interactions with that feature, which warrants a caution about unnecessary interactivity that may hinder simulation efficiency. The authors concluded that neither prior knowledge of chemistry nor the age of the participants has a significant effect on either the number of interactions or the ability to follow on-screen instructions.

In the paper entitled *Exploring the Impact of and Perceptions about Interactive, Self-Explaining Environments in Molecular-Level Animations,* A. Falvo, M. J. Urban and J. P. Suits report on a study of university students' perception of using interactive animations of the submicroscopic level of chemistry concepts in the learning process. Using the mixed method of pedagogical research, the authors also investigate perceptions of the animated learning tool used. This study explores principles of cognitive psychology designed to investigate the main effects of treatment and spatial ability and their interaction. The results show that science majors score more highly than non-science majors in retention measures (i.e., structure and function) but not in transfer. Significant main effects were found for treatment in function questions and spatial ability in structure questions. There was a significant interaction between treatment and spatial ability in structure questions. Additionally, the authors of this study reported that participants believed the key and the motion of ions and molecules were the most helpful parts of the animation. The study also shows that students perceive the animations as being supportive of their learning, suggesting that animations do have a role in science classrooms.

The last contribution to this thematic issue about visualisation in education is entitled *Visualisation of Animals by Children: How Do They See Birds?*, in which S. D. Tunnicliffe describes pupils' mental models of birds. She emphasises the fact that children learn to recognise animals from their earliest years through actual sightings in their own observations of their world, but also through second-hand representations in various forms of media. Young learners begin with a template specimen, to which they refer when they see another animal that resembles it, naming the animal accordingly. Gradually, they learn to distinguish members of the subordinate category – bird in the case of the present paper – into subcategories. The author examined drawings as a means of accessing students' mental models, and through their interpretation she studied students' representations of both phyla and species. She also used interviews with participants in order to explain the students' drawings. The results show that as children mature they observe more and more details about the birds they see, thus increasing their knowledge not from school but from their own observations outside school.

Later in this edition, we find one paper in the Varia section by B. Šteh and J. Kalin, entitled *Building Partner Cooperation between Teachers and Parents*. The authors present the goals of teacher-parent cooperation, various potential models of establishing mutual cooperation, and conditions for achieving quality interactive cooperation. They discuss the partnership model as the optimal model of interactive cooperation between teachers and parents, as it includes the distribution of expertise and control with the purpose of ensuring optimal education for children. In the second part of the paper, B. Šteh and J. Kalin present findings of an empirical study carried out on a representative sample of Slovene primary schools. Teachers and parents were asked to give their opinions regarding the need for mutual cooperation, to express their view of each other when fulfilling their respective roles, and to state where they perceive the main obstacles to mutual cooperation. The results show that building positive mutual relationships between teachers and parents is a prerequisite for improving successful cooperation.

In the third part of the present issue of the CEPS Journals, there are two reviews of monographs. The first book is entitled *Facilitating Effective Student Learning through Teacher Research and Innovation* (2010) by editors Valenčič Zuljan, M. and Janez, V., published by the Faculty of Education of the University of Ljubljana (ISBN 978-961-253-051-8), and the second is entitled *Play Space [Prostor igre]* (2011) by Tomšič Čerkez, B. and Zupančič, D., published by the Faculty of Education and the Faculty of Architecture of the University of Ljubljana (ISBN 978-961-253-053-2).

Iztok Devetak

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In-Service Science Teachers' Technological Pedagogical Content Knowledge Confidences and Views about Technology-Rich Environments

Betül Timur[1] and Mehmet Fatih Taşar*[2]

Today's computers and related technologies have an important role in enabling visualisations of the workings of various scientific concepts, natural phenomena and mechanisms by creating technology-rich environments (TRE). TRE offer opportunities to science teachers in cases of natural phenomena that might be difficult or impossible to view, dangerous to conduct experiments about, impractical or too expensive to bring into the classroom, or too messy or time consuming to prepare in a school laboratory. However, science teaching cannot and should not be undertaken entirely by TRE. Science teachers need to know how to integrate technology into science classrooms. Measuring science teachers' confidence in technological pedagogical content knowledge (TPCK) and identifying their views about using TRE in science instruction is an important issue. The present study aims to address challenges faced by in-service science teachers when creating TRE and gives suggestions for successful technology integration into science teaching. The data were gathered through a TPCK confidence survey and subsequent interviews. The results show that in-service science teachers have a low level of confidence in using technology during science teaching. The teachers surveyed stressed their need for professional development activities regarding the effective and meaningful use of TRE in science teaching.

Keywords: In-service teachers, Mixed methods research, Teacher confidence, Technological pedagogical content knowledge, Technology-rich environments

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Samozaupanje učiteljev naravoslovja v njihovo tehnološko-pedagoško znanje in njihova stališča do tehnološko bogatih okolij

Betül Timur in Mehmet Fatih Taşar*

Danes imajo računalniki in z njimi povezane informacijsko-komunikacijske tehnologije (IKT) v t. i. tehnološko bogatih okoljih (TBO) pomembno vlogo pri vizualizaciji različnih naravoslovnih pojmov in pojavov. TBO učiteljem naravoslovja nudijo možnosti prikaza naravoslovnih pojavov, ki jih je težko ali nemogoče videti, nevarno izvajati, so nepraktični ali predragi, da bi se jih prineslo v učilnico, njihovo izvajanje povzroči preveč nereda ali pa so časovno preveč neekonomični, da bi se jih dalo prikazati v šolskem laboratoriju. Kljub temu pa se pouk naravoslovja ne more in tudi ne sme v celoti izvajati s pomočjo TBO. Učitelji naravoslovja morajo poznati smernice učinkovite integracije IKT v pouk. Pri tem je pomembno, da se določi samozaupanje učiteljev naravoslovja v svoje tehnološko-pedagoško znanje in ugotovi njihova stališča do uporabe TBO pri pouku naravoslovja. Cilji te študije so ugotoviti, s katerimi izzivi se srečujejo učitelji naravoslovja med ustvarjanjem TBO, in podati predloge za uspešno integracijo IKT v pouk naravoslovja. Podatki so bili zbrani z uporabo vprašalnika o samozaupanju učiteljev v svoje tehnološko-pedagoško znanje in intervjuji. Izsledki kažejo, da imajo učitelji naravoslovja nizko samozaupanje v znanje o uporabi IKT pri pouku naravoslovja in da poudarjajo pomen profesionalnega razvoja na področju TBO, da bi IKT lahko učinkovito in smiselno vključevali v pouk.

Ključne besede: tehnološko bogato okolje, tehnološko-pedagoško znanje, učitelji, samozaupanje učiteljev

Theoretical background

Towards the end of the last century, we witnessed the beginning of the widespread use of computer technologies in science classrooms, and practically everywhere else, as personal computer hardware with ever higher capacities became affordable to larger populations and applications with enhanced visual characteristics were created with less effort, not only by computer experts but also by science educators. Although not sufficient for all teachers, several initiatives and efforts emerged in order to help science teachers to better understand the associated teaching methodologies and the benefits of technology-rich environments (TRE) in science.

In the coming years, computing is expected to become increasingly effective and indispensible in the processes of science, as is expressed in the "Towards 2020 Science" report: "Scientists will need to be completely computationally and mathematically literate, and by 2020, it will simply not be possible to do science without such literacy. This therefore has important implications for education policy right now" (The Science Group, 2006, p. 8). By reviewing existing empirical studies, however, a recent paper (Hew & Brush, 2007) identified 123 barriers faced by teachers. The authors classified these barriers into six main categories: (a) resources, (b) knowledge and skills, (c) institutions, (d) attitudes and beliefs, (e) assessment, and (f) subject culture.

In an OECD report entitled "21st Century Learning Environments", the role of schools is specified as follows: "Today, ICT skills – from completing a simple search on the Internet and writing an essay in Word, to cutting a video and designing a Web page – are a prerequisite for entry into the workforce. Schools have an important role to play in providing students with the necessary skills to become tomorrow's knowledge workers" (OECD, 2006, p. 20). In-service science teachers have an important role to play creating successful TRE in science teaching.

Science teachers' technological pedagogical content knowledge

Technological pedagogical content knowledge (now known as TPCK or TPACK) has become a commonly referenced conceptual framework of teacher knowledge for technology integration within teacher education. TPCK is described as a complex interaction of content, pedagogy and technology, as well as discussion on the successful integration of technology into instruction (Koehler & Mishra, 2008). In recent years, researchers have described TPCK within the framework Schulman's (1986, 1987) description of pedagogical content knowledge (PCK).

According to Schulman (1986, p. 9), PCK "goes beyond the knowledge of subject matter per se to the dimension of subject matter knowledge for teaching", thus being the connection and relationship between pedagogy and content knowledge. Researchers have conceptualised PCK in the domain of teaching with technology using different schemes: "Margerum-Lays and Marx (2003) referred to PCK of educational technology, Slough and Connell (2006) used the term technological content knowledge, and Mishra and Koehler (2006) suggested the term technological pedagogical content knowledge (TPCK) – a comprehensive term that has prevailed in the literature" (as referred to and cited in Angeli & Valanides, 2009, p. 155). TPCK can be described as how teachers understand educational technologies and how PCK interacts with technology to produce effective teaching with technology. Table 1 shows the PCK conceptualisations of ten scholars.

Mishra and Koehler's (2006) definition of TPCK is that "[it is] the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones." On the other hand, Angeli and Valanides (2009) assert that "content, pedagogy, learners, and technology are contributing knowledge bases to TPCK, but knowledge and growth in each contributing knowledge base alone, without any specific instruction targeting exclusively TPCK as a unique body of knowledge, does not imply automatic growth in TPCK". The authors go on to relate ICT to TPCK, defining TPCK in the following manner: "the ways knowledge about tools and their pedagogical affordances, pedagogy, content, learners, and context are synthesized into an understanding of how particular topics that are difficult to be understood by learners, or difficult to be represented by teachers, can be transformed and taught more effectively with ICT, in ways that signify the added value of technology."

Table 1: Components of Pedagogical Content Knowledge from different conceptualisations (Van Driel, Verloop & De Vos, 1998; Park & Oliver, 2008).

Scholars	Knowledge of								
	Purpose for teaching a subject matter	Student understanding	Curriculum	Instructional strategies and representations	Media	Assessment	Subject matter	Context	Pedagogy
Shulman (1987)	d	PCK	d	PCK	–	–	d	d	d
Tamir (1988)	–	PCK	PCK	PCK	–	PCK	d	–	d
Grossman (1990)	PCK	PCK	PCK	PCK	–	–	d	–	–
Marks (1990)	–	PCK	–	PCK	PCK	–	PCK	–	–
Smith and Neale (1989)	PCK	PCK	–	PCK	–	–	d	–	–
Geddis et al. (1993)	–	PCK	PCK	PCK	–	–	u	–	–
Fermandez et a. (1995)	PCK	PCK	u	PCK	–	–	PCK	PCK	–
Magnusson et al. (1999)	PCK*	PCK	PCK	PCK	–	PCK	–	–	–
Hasweh (2005)	PCK	PCK	PCK	PCK	–	PCK	PCK	PCK	PCK
Loughran et al. (2006)	PCK	PCK	–	PCK	–	–	PCK	PCK	PCK

PCK: Author(s) include this subcategory as a component of PCK.

d: Author(s) place this subcategory outside PCK as a distinct knowledge base for teaching.

* Researchers in science education refer to this component as one's "orientation toward teaching".

The aim of the study and research questions

The present study aims to measure in-service science teachers' TPCK confidences and identify their views about using technology-rich environments (TRE) in science. We also aim to address challenges faced by in-service science teachers in creating TRE, and to give suggestions for successful technology integration in science teaching.

The study focuses on the following research questions:

1. What are in-service science teachers' perceived confidence levels in four TPCK constructs (i.e., technological knowledge, technological pedagogical knowledge, technological content knowledge, technological pedagogical content knowledge)?
2. What are in-service science teachers' views, needs and classroom practices regarding TRE?

Method

Participants

A non-random purposeful sample was used to gather data from in-service science teachers. Ninety-five public school science teachers participated in the survey on a voluntary basis. Sample characteristics are summarised in Table 2.

Table 2: Participants' characteristics.

Participants' characteristics	F	%
Gender		
Female	44	46.3
Male	51	53.7
Teaching hours per week		
10-14	10	10.5
15-19	35	36.8
20-24	38	40.0
25-19	10	10.5
29-34	2	2.1
Number of students in teacher's classroom		
Less than 20	10	10.5
21-30	60	63.2
31-40	21	22.1
41-50	4	4.2
Teacher's professional experience		
1-5 years	17	17.9
6-10 years	35	36.8
11-15 years	23	24.2
16-20 years	13	13.7
More than 21 years	7	7.4

Instruments

The TPCK confidence-science instrument has been adapted to Turkish from Graham, Burgoyne, Cantrell, Smith, Clair and Harris (2009).

The original survey instrument was created by Graham et al. and consists of 31 Likert-type items. Respondents were asked: "How confident are you in your current ability to complete each of the following tasks?" Responses were given in the form of 6-point Likert-type questions: 1=not confident at all, 2=slightly confident, 3=somewhat confident, 4=fairly confident, 5=quite confident, 6=completely confident (the scale for TCK items also had 0=I don't know about this kind of technology). The areas of TPCK, TPK, TCK and TK were created by combining the domains of content, pedagogy and technology. The original instrument contains eight items related to TPCK, seven items related to TPK, five items related to TCK, and 11 items related to TK in order to measure in-service science teachers' TPCK confidence.

Survey adaptation steps suggested by Brislin (1970), White and Elander (1992) were used in the present study (as cited in Hall, Wilson, & Frankenfield, 2003). The steps were: "1) use short and simple language; 2) secure competent translators who are familiar with the issue; 3) have a refinement group for both translations", while the back-translation method was considered to be the preferred method of obtaining a culturally equivalent instrument (Erkut, Alarcon, Garcia Coll, Troop, & Vazguez Garcia, 1999). After translating the instrument into Turkish, a back translation into English was made for checking purposes. First, three native Turkish speakers made their translations independently. Two of the translators hold PhD degrees in science education and the other is a lecturer at the Department of Computer and Instructional Technologies Teaching. The authors compared these three translations and formed a Turkish version of the instrument for back translation. Second, three back translations into English were made by three independent Turkish individuals with PhD degrees. Finally, the authors compared the three back translations and created the final version of the instrument for the main study.

A revised version of the scale was administered to 393 science and technology teachers to determine its validity and reliability. A factor analysis method yielded the construct validity of the scale. Confirmatory factor analysis (CFA) was used to ensure compliance with Turkish culture. The instrument consisted of 31 items and four dimensions: technological pedagogical content knowledge (TPCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK) and technological knowledge (TK). Reliability analysis of the instrument revealed that the Cronbach-Alpha coefficient was very high (.92) for the whole instrument. The reliability coefficients of the four sub-dimensions were also very high, at .89, .87, .89 and .86 respectively for the TPCK, TPK, TCK, and TK sub-dimensions (Timur & Taşar, 2011). These results showed that TPCK confidence can be used in Turkey for measuring the TPCK confidence of in-service teachers. The sample items for each dimension are given in Table 3 below.

Table 3: Sample items of the TPCK confidence survey for each dimension.

Sub-factor	Sample items
TPCK	– use online animations that effectively demonstrate a specific scientific principle, – help students use digital technologies to organise and identify patterns in scientific data, – use digital technologies that facilitate topic-specific science activities in the classroom,
TPK	– use digital technologies to motivate learners, – use digital technologies to help in assessing student learning,
TCK	– use digital technologies that allow scientists to observe things that would otherwise be difficult to observe, – use digital technologies that allow scientists to speed up or slow down the representation of natural events,
TK	– create and edit a video clip, – create a basic presentation using PowerPoint or a similar programme.

Additionally, face to face semi-structured interviews were conducted with four of the participants. Interviews were conducted with two male and two female science teachers. Four questions were asked in order to probe how they create TRE in their classrooms. The following questions were asked during the interviews: (1) For what purposes do you use computers in teaching science? (2) What are the barriers to TRE in teaching science? (3) How do you currently use computers to support your science teaching? and (4) How do you create TRE in science teaching?

Research design

Both quantitative and qualitative research methods were used to investigate the level of TPCK confidence. The instrument was emailed to more than 450 in-service teachers. The survey was completed and returned by 101 teachers, but six of the respondents were excluded due to missing data.

The data were analysed using the Statistical Package for the Social Sciences (SPSS), and semi-structured interviews with the teachers were recorded in audio and transcribed verbatim. The aim of the interviews was to collect more detailed data from the participants, and to find out the in-service science teachers' views, needs and classroom practices regarding TRE. Qualitative research must show enough detail for the reader to be able to see the case clearly in order for the researcher's conclusion to make sense (Creswell, 1998).

Results

In order to address the question of the perceived confidence level of in-service science teachers' related to the four TPCK constructs, teachers were asked, "How would you rate your confidence in doing the following tasks associated with technology usage?" Thirty-one items in the areas of technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPCK) were asked, and responses were made on a 5-point scale reflecting the level of confidence. Means were calculated for all items, and the average mean for the four sub-factors is shown in Table 5, while Table 4 shows the ranges of confidence levels formed.

Table 4: The confidence intervals for the Likert scale.

Interval Range	Confidence Level
1.00–1.79	not confident at all
1.80–2.59	slightly confident
2.60–3.39	somewhat confident
3.40–4.19	fairly confident
4.20–5.00	completely confident

Table 5: Summary of descriptive statistics for sub-factors for the question, "How would you rate your confidence in doing the following tasks associated with technology usage?"

Sub-Factor	Scale					Item	
	No. of Items	Min.	Max.	Mean	SD	Mean	SD
TPCK	8	8.00	40.00	25.63	7.24	3.20	0.91
TPK	7	11.00	35.00	22.24	5.30	3.18	0.76
TCK	5	5.00	25.00	15.82	4.88	3.16	0.98
TK	11	18.00	55.00	36.62	9.71	3.33	0.88

According to their responses, the teachers asserted that they feel somewhat confident in all of the four sub-factors. However, they asserted that of the four sub-factors they feel most confident in technological knowledge (TK_{mean}=3.33). They feel somewhat confident in their knowledge of how to use technology and how to teach more effectively with technology, as well as to help students meet any specific curriculum content and to use technologies appropriately in their learning. "In other words, merely knowing how to use technology is not the same as knowing how to teach with it" (Mishra & Koehler, 2006).

The second research question was "What are in-service science teachers' views, needs, and classroom practices regarding TRE?" In order to answer this question, five questions were put to 95 in-service science teachers, and semi-structured interviews were conducted with four teachers.

In their responses to the questions about TRE, teachers asserted that computer facilities at their schools are not good enough to create TRE, so they generally give computer-based instruction to the whole class. They also asserted that almost all teachers require professional development regarding how to use computers in science instruction. There is a need to provide technological pedagogical content knowledge confidence to in-service science teachers in order to create optimally functioning technology enhanced classrooms.

Table 6: Descriptive statistics of teachers' views about TRE in science.

Computer facilities	f	%
Computer facilities at the school		
No computers at school	6	6.3
One computer in each class	28	29.7
Computer lab at school	41	43.2
One computer used for several classes	20	21.1
Hours per week of computer-based instruction		
1	17	17.9
2	33	34.7
3	17	17.9
4	11	11.6
More than 4	17	17.9
Group size in classes with computer-based instruction		
One computer for each student	5	5.3
One computer for two students	8	8.4
Small groups	11	11.6
Whole class	71	74.7
Computer-based instruction years		
0	10	10.5
1-5	72	75.7
6-10	13	13.8
Need for professional development regarding using a computer for instruction in science		
Yes	74	77.9
No	21	22.1

Teachers asserted that they use computers for showing animations, simulations, videos and films, and for making representations with PowerPoint during instruction. The barriers to TRE were: lack of access to Internet at school; difficulty in locating and executing technology-rich materials, such as animations, simulations and videos, for every subject; the pre-class planning and preparation required to create TRE; and classroom management problems. Teachers tend to group the whole class for TRE and show animations, simulations and videos using a projector. They asserted that they sometimes stop the video or animation and ask the class questions about the subject. One teacher described the current use of computers in his science instruction as follows:

I usually use animations or videos in instruction. It is difficult to find visualisations for every subject in science since most science subjects are abstract. I have to spend time preparing in order to create technology-rich science lessons. However, students in my class are highly motivated when I use visualisations in my science teaching. In the last lesson, I used a cartoon animation of blood cells in my class. The whole class watched the animation together and solved a puzzle after the animation. However, sometimes watching a video or animation in a science lesson cannot be different from watching a movie at the cinema.

Another teacher described her technology-rich class as follows:

I use a projector when I use a computer in my class. I arrange students' seats in the best way for them to see the whiteboard. I start the lesson with brainstorming about the subject then we watch a video or animation. I do not usually have classroom management problems because students are highly motivated when they are watching a video or animation. However, sometimes students find their peers' questions ridiculous or foolish.

Conclusions

The present study shows that in-service science teachers do not have sufficient TPCK confidence to create TRE in science teaching, and that they need professional development on the use of TRE in science teaching. Teachers need to have confidence to use technology as an enrichment rather than as a replacement in science teaching. Koch (2005, p. 25) emphasises that technology alone cannot help students to learn science. As she explains, a computer can become part of the science learning experience if the child feels a need to use it in learning, and such a need can be created, for example, while exploring what causes different weather conditions. In this case, students can easily access weather reports on the Internet. This act makes the computer a useful and meaningful tool in learning. Such use can also be found in many other computer applications (e.g., certain software packages and online resources) that allow students to explore science phenomena in a simulated environment. In a way, access to interactive manipulation of the simulated phenomena forms a science laboratory that allows the child to study and learn at her or his convenience. Successfully integrating technology into science education relies heavily on the development of well-built, coherent professional development programmes that are designed with a clear understanding of how teachers can use technology in their class in the most effective way.

Some recent studies have focused on the barriers effecting technology integration, such as limited access to the Internet, classroom size and lack of teacher knowledge about successful technology integration into instruction (Çakır & Yıldırım, 2009; Cure & Özdener, 2008). Other research indicates that PD programmes have a positive impact on teacher development of TPACK (Guzey & Roehrig, 2009; Graham et al., 2009; Varma, Husic & Linn, 2008) and can help teachers to successfully integrate technology into their practice (Niess, 2005; Harris, Mishra, & Koehler, 2009).

There is a need to provide TPCK confidence to in-service science teachers in order to create optimally functioning technology-enhanced classrooms. It is important to devote time and effort to PD programmes, to exploring the cognitive, transformative and pedagogical aspects of adopting educational technology in teaching, rather than merely presenting the hardware and software to be used (Sturdivant, Dunham, & Jardine, 2009).

Recent reports of the Turkish Education Association (2009, p. 174) regarding teacher competences assert that both in-service and pre-service teachers need to have technology competences, or so-called technological pedagogical content knowledge. They have to know how to integrate technology into their instruction and create effective technology-rich environments. Recent studies of teacher competences in creating TRE show that primary school teachers fail to use instructional software in their lessons, and that most teachers do not even know whether there is any software available in their fields (Kazu & Yavuzalp, 2008). On the other hand, instructional software is inadequate at primary and secondary school level, and the existing instructional software is not aligned with the subjects in the primary and secondary school curriculum. Furthermore, although primary science teachers and secondary physics teachers believe that it is effective to use computers in instruction, they do not know how to do so and need professional development and support in this area (Uzal, Erdem, & Ersoy, 2009). In another study, it is stated that primary school teachers have inadequate competences for using computers in instruction (Balkı & Saban, 2009). In light of these results, in our professional development we will focus on the development of in-service science teachers' technological pedagogical content knowledge, and aim at increasing student achievement in primary school science lessons by utilising interactive computer animations in Force and Motion course subjects.

Successfully integrating technology into science education relies heavily on the development of well-built, coherent professional development programmes that are designed with a clear understanding of how teachers need to use technology in their class in the most effective way. Science teachers need to have the competence of technological pedagogical content knowledge in their particular discipline.

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Biographical note

Betül Timur, Assist. Prof., completed her Ph.D. at Gazi University with a thesis on the development of pre-service science teachers' technological pedagogical content knowledge. She has been teaching science education courses including special topics in physics, science-technology-society, and science teaching since 2007. Her main research interests are inquiry based science, place and importance of science process skills, and technological pedagogical content knowledge.

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Student Engagement with a Science Simulation: Aspects that Matter

Susan Rodrigues*[1] and Eugene Gvozdenko[2]

It is argued that multimedia technology affords an opportunity to better visualise complex relationships often seen in chemistry. This paper describes the influence of chemistry simulation design facets on user progress through a simulation. Three versions of an acid-base titration simulation were randomly allocated to 36 volunteers to examine their interactions with the simulation. The impact of design alterations on the total number of interactions and their patterns was analysed for the following factors: (a) the place of a feature on the screen, (b) alignment of the sequence of instructions, (c) additional instruction before the simulation, (d) interactivity of a feature. Additionally, interactions between individual factors, such as age, prior experience with science simulations and computer games, perception of the difficulty of science simulations, and general subject knowledge, on one hand, and the efficiency of using the simulation, on the other hand, were examined. The findings suggest that: (a) centrality of the position of an element significantly affects the number of interactions with the element, (b) re-arranging the sequence of instructions on the screen in left-to-right order improves the following of instructions, (c) providing users with additional written advice to follow numbered instructions does not have a significant impact on student behaviour, (d) interactivity of a feature was found to have a strong positive correlation with the number of interactions with that feature, which warrants a caution about unnecessary interactivity that may hinder simulation efficiency. Surprisingly, neither prior knowledge of chemistry nor the age of the participants had a significant effect on either the number of interactions or the ability to follow on-screen instructions.

Keywords: Chemistry, Educational simulations, Learning, Instructions, Interactivity, Simulation design

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Interakcija študentov z naravoslovnimi simulacijami: pomembni vidiki

Susan Rodrigues* in Eugene Gvozdenko

Multimedijska tehnologija naj bi nudila možnosti boljše predstavitve kompleksnih odnosov med pojmi, ki se pogosto pojavljajo pri kemiji. Prispevek podaja vpliv dizajna kemijske simulacije na napredek posameznika pri uporabi simulacije. Tri različice simulacije na temo titracije kisline z bazo so bile naključno predstavljene 36 prostovoljcem, da bi raziskali njihovo interakcijo s simulacijo. Vpliv treh različnih oblik dizajna simulacij na skupno število in vzorec interakcij posameznika s simulacijo je bil analiziran glede na: a) mesto elementa na zaslonu, b) položaj zaporedja navodil, c) dodatna navodila pred simulacijo in d) interaktivnost elementa. Dodatno so bile raziskane še povezave med starostjo, predhodnimi izkušnjami z naravoslovnimi simulacijami in računalniškimi igrami, dojemanjem zahtevnosti naravoslovnih simulacij, znanjem kemijskih pojmov in učinkovitostjo študentov pri uporabi simulacij. Ugotovitve kažejo, da: a) centralna postavitev določenega elementa v simulaciji pomembno vpliva na število interakcij s tem elementom, b) razporeditev zaporedja navodil na zaslonu od leve proti desni izboljša sledenje navodilom, c) dodatna pisna navodila uporabnikom, da naj sledijo oštevilčenim navodilom, ni imela pomembnega učinka na vedenje študentov, d) korelacija med interaktivnostjo elementa in številom interakcij s tem elementom je pozitivna, močna in pomembna, kar kaže na to, da je treba biti pri snovanju simulacij previden, da ne omogočamo nepotrebnih interaktivnosti, ki lahko zavirajo učinkovitost simulacije. Presenetljivo je, da predznanje kemije in starost udeležencev nista imela pomembnega vpliva na število interakcij in zmožnost sledenja navodilom na zaslonu.

Ključne besede: učenje, kemija, izobraževalne simulacije, oblikovanje simulacij, interaktivnost, navodila

Introduction

Information communication technology (ICT) has become ubiquitous as it has become more affordable and more powerful (Madden et al., 2005). By 2008, approximately 66% of British homes had Internet connection, (Office for National Statistics, 2008) and in more recent years, a change in connection to the Internet in the form of broadband has reduced the need for homes to have a computer-dedicated line, increased the speed of data transfer, and allowed for increased use of multimedia within web pages. Valentine, Marsh and Pattie (2005) found that the majority of children used their home computer for school work. Over ten years ago, when Rideout, Foehr and Roberts, (1999) asked a representative sample of American children aged 8–18 which medium they would take to a desert island, the preferred choice was a computer with Internet access. Thus it is not surprising that over recent decades, schools, researchers and policy makers have all shown growing interest in the use of ICT to support classroom teaching and learning.

As a consequence, we have seen increasing literature reporting on various forms of ICT for science education. This literature has included reporting on the use of audience response systems (Rodrigues, Taylor, Cameron, Syme-Smith, & Fortuna, 2010), dataloggers (Tortosa, Pinto, & Saez, 2008), email (Van derMeij & Boersma, 2002), the Internet (Mackenzie, 2010), modelling (Pallant & Tinker, 2004), simulations (Eilks, Witteck, & Pietzner, 2010), virtual character research (Rebolledo-Mendez, Burden, & de Freitas, 2008) and whiteboards (Redman, McDougal, & Rodrigues, 2010). Within this body of work, one can also find research linking the culture of informal computer games, student interest and the development and design of appropriate ICT for chemistry (see Prensky, 2004; Grimley et al., 2010), as well as work on attitudes (Tondeur, Van Keer, van Braak, & Valcke, 2008). In the present paper, we consider more than just the motivational aspect; we look at the process of engagement and the influence of the design element in terms of supporting cognitive and skill development in science education.

Designers' views of learners and their assumptions about learning theories, learning processes and learning practices ensure that content and pedagogy are intertwined before the technology reaches the classroom (Segall, 2004). Consequently, multimedia design for school purposes has been explored and continues to be explored, resulting in a debate about the influence of various factors in supporting or hindering learning.

Mayer, Sobko and Mautone (2003) define multimedia learning as the use of at least two different types of media (graphics, audio, video and text) in presenting information. Clarke and Mayer (2003), Ginns (2005) and Moreno (2006) reported a modality principal and suggested that graphical information explained by onscreen text and audio narration led to cognitive overload and was therefore detrimental to learning. In more recent times, studies (see Dunsworth & Atkinson, 2007; Sanchez & Garcia-Rodicio, 2008) suggest that there is no difference in performance based on the presence or absence of audio narration. Eilks et al., (2010) suggested that technology that allows for a seamless interchange between tables, charts, graphs and model displays could support conceptual linking between these representations. Ploetzner, Bodemer and Neudert (2008) suggest that the required high transfer rate may, unfortunately, result in a limited attention span. Testa, Monroy and Sassi (2010) suggest that graphs depicted in textbooks are 'cleaned' of redundant details/irregularities, whereas technology-generated real-time graphs include 'noise', resulting in some learners finding them challenging to interpret. Indeed, the argument pertaining to computer-based graphing exercises has had a long lifespan. For example, the Brasell (1987) study suggested that a delay in display, even if less than 30 seconds, resulted in subduing nearly all students, for they demonstrated less engagement and became preoccupied with procedural issues. However, Beichner (1990) suggested that student engagement could be lowered if the software constructed the graphs. Schnotz and Bannert (2003) suggested that picture use in multimedia learning processes may not be beneficial in every case, while Schwartz, Andersen, Hong, Howard and McGee (2004) and Azevedo (2004) suggest the use of non-linear learning environments may result in inadequate metacognitive competencies. Paivio's dual coding theory (2006) suggests that multiple references to information with connections between verbal and non-verbal (imagery) processing improves the learning process. Chandler and Sweller's (1991, 1992) 'split attention' effect (with the learner addressing multiple information sources before trying to integrate the segments to make them intelligible) and their 'redundancy' concept suggest that disparate sources may generate cognitive overload. Paivio (2006), Chandler and Sweller (1991, 1992) may appear to hold contradictory views, but both sets of ideas seem feasible and at present neither explanation has more currency than the other.

In light of these various arguments, and given the growing use and production of simulations and animations in school chemistry, we decided to explore the influence of chemistry simulation design facets on user progress through a simulation. It is argued that multimedia technology affords an opportunity to better visualise complex relationships. We were interested in the scope of this opportunity and hence developed the following research questions:

- *What are the differences in the nature of student interactions associated with an altered simulation design format?*

- *What are the effects of the changes in instruction formats on the process of students' engagement behaviour?*
- *How effective are additional written instructions before the simulation?*
- *How does altering the position of controls on the simulation screen affect students' engagement with the simulation?*

Method

Participants

The convenience sample included 57 volunteers from four schools and one tertiary institution. The data collected did not identify the volunteers on a personal level. They were anonymously allocated individual codes when they accessed the website and the different institutions were recognised by the log. The volunteers were asked to provide their age, gender, science subject (science, chemistry, physics, biology) and class/tertiary level, as well as to indicate their previous ICT experience and complete five multiple choice chemistry questions pre-simulation use and post-simulation use. Fifty-seven volunteers submitted required information and 36 of them interacted with the simulation. The data collected from the volunteers who submitted questionnaires and actually interacted with a simulation provided were used for the analysis presented in the present paper.

Among the 36 participants, there were 19 students aged 13–15 years (second year of secondary school) and 15 students aged 16 and over. Two participants did not indicate their age. There were roughly equal numbers of male and female participants (17 females and 16 males) using this simulation. Three participants did not supply details about gender.

Table 1: Descriptive statistics of the sample.

Sample description		Simulation versions		
		1	2	3
Gender	Male	5	5	6
	Female	1	8	8
	Not indicated	0	1	2
Age	13-15	2	7	10
	16 and over	3	7	5
	Not indicated	1	0	1

Science	Chemistry	0	4	5
	Physics or Biology	1	2	0
	Combination	2	8	8
	Not indicated or none	2	0	3
Playing PC games	Yes	4	8	11
	No	1	5	4
	Not indicated	1	1	1
Prior experience in using simulations in Science lessons	Yes	4	6	12
	No	1	7	3
	Not indicated	1	1	1

Research design

Professor Thomas Greenbowe (2005) kindly provided access to the code for two of his flash-based simulations (a titration and reactivity of metals) available on the internet as learning resources aimed at introducing college chemistry (general chemistry). We modified the code to create three versions of each simulation and to add a facility for monitoring users' interactions with the simulations. A system was created that randomly allocated one version of the two simulations to each user as they accessed the website. A log of all mouse clicks and interactions with the simulation controls (buttons, sliders, text fields and selection boxes) was generated for each user. The computer tracked the time that the user spent on each stage and on each particular element of the simulations.

This behind-the-scenes recording of activity was chosen for three reasons. Firstly, we felt it would be less intrusive, and that it therefore had the potential to generate more reliable data. Secondly, collecting images of school children is increasingly discouraged by local authorities. Thirdly, the url was available for use outside the classroom, and filming its use in that milieu would be impractical.

Each user had to complete a pre-simulation questionnaire (specific to the chemistry topic for the simulation being viewed) before being randomly allocated one of three versions of the simulation. After the simulation, they were asked to complete a post-simulation test and a post-questionnaire. The pre-simulation and post-simulation chemistry questions were based on those found in standard textbooks. However, these questions are not discussed here, as the present paper focuses on patterns of interaction and engagement. Figure 1 provides an overview of the sequence.

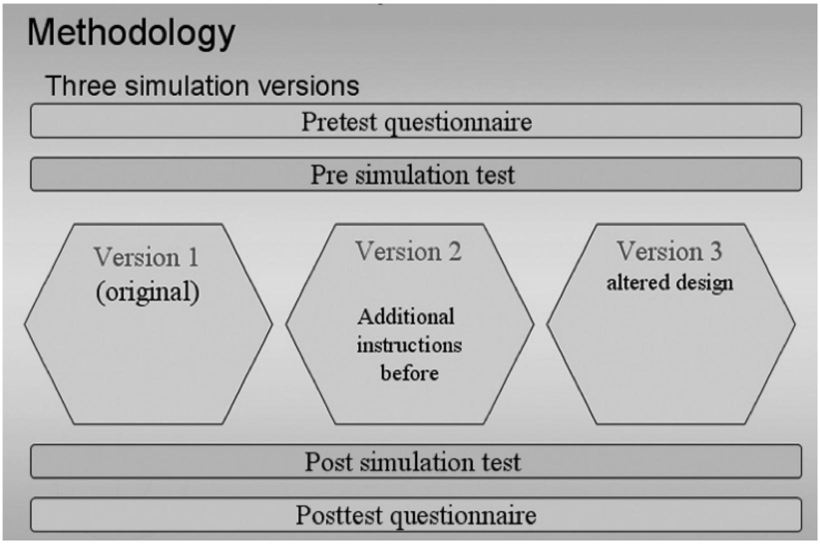

Figure 1: Experimental design.

The simulations

The simulations we used probably best fit within the Thomas and Hooper (1991) category of 'experiencing simulations'. Experiencing simulations model particular scenarios, allowing students to manipulate factors to see their impact or influence. The simulations we used were representative of many common types of simulations used in school science lessons. However, by selecting an acid-base titration simulation aimed at 'college level' we were able to explore the influence of age and, consequently, prior experience factors on user ability to follow instructions, as while the acid-base titration would be familiar to older students it would be completely novel to the younger students in our sample cohort. The 13-year-old students would have encountered the terms acid and base, but in our experience they would not have conducted a titration during practical or wet-lab work in schools. Our sample also included first-year university chemistry undergraduate students, who almost certainly would have conducted titrations during their senior years at school and during their first year at university.

The acid-base titration simulation had three versions: the original version (Version 1), a modified version (Version 2) that included a one paragraph pre-text advising students to pay attention to particular aspects (as can be seen in Figure 2), and another modified version (Version 3) that had altered positions for specific elements on the screen (as can be seen in Figure 3).

The following is the excerpt paragraph that appeared on the webpage before the Version 2 titration simulation loaded:

> "When you click on the button below you will see a simulation that represents a titration. To make the simulation work you must follow the numbered instructions in sequence. So start with instruction 1, then 2, then 3, etc. Some instructions have tabs. You must place the mouse on the tab and drag it open".

In Version 3, a menu tab, also identified with the number 3 on the simulation "Select the Acid and Base", was converted from a 'pull out tab' menu to a fixed position, visible menu. The position of other items on the screen was also modified so that the sequence of instructions was aligned with a common reading pattern (horizontal sequence of left to right) (Gvozdenko et al., 2010).

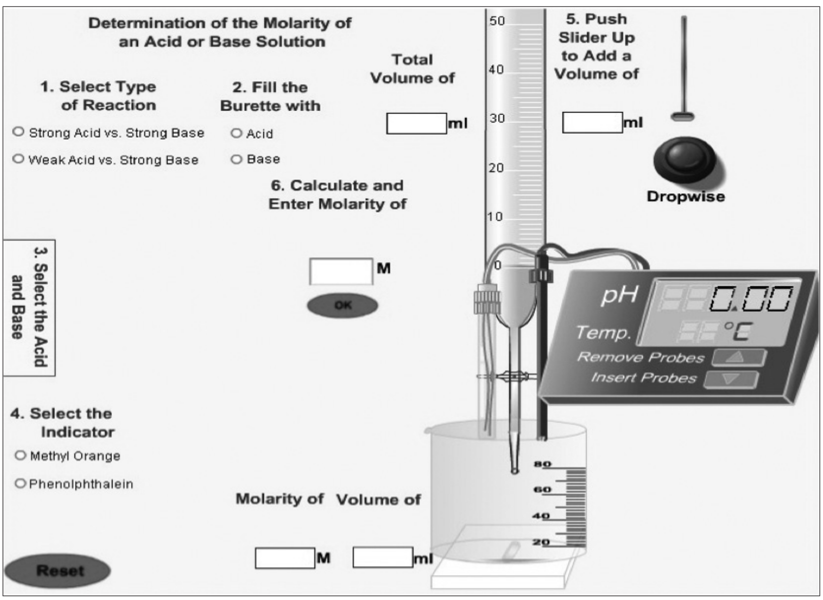

Figure 2: Titration simulation Versions 1 and 2.

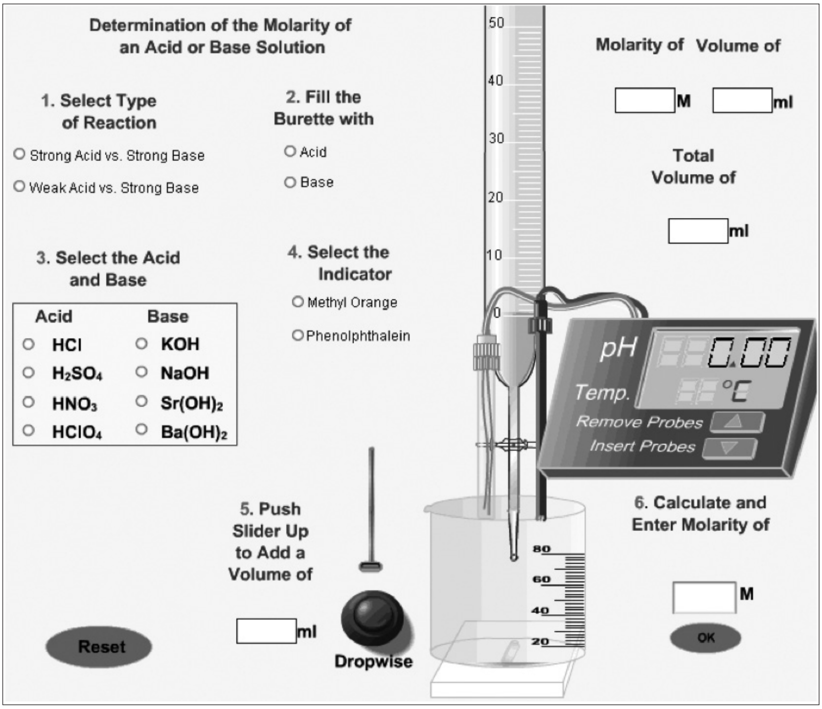

Figure 3: Titration simulation Version 3.

Data analysis

We used one-way unrelated analysis of variance (ANOVA) to determine whether the different versions of the acid-base titration simulation had an impact on how students followed the sequence of instructions. Each simulation version involved a separate and unrelated sample of subjects, so we assumed equal population variation and normal distribution of our random population within the different version cohort. The one-way ANOVA allowed us to deduce the mean for the three versions and then compare these means between the versions. Calculating the one-way ANOVA and the variation between scores meant we could compare the variation between sample means for each simulation version. In the null hypothesis, the assumption was that the mean for Version 1 was the same as the mean for Version 2 and Version 3. However, if the one-way ANOVA showed that the variation between the samples was bigger than the variation in the population, we would have to accept the alternative hypothesis, i.e., that the variation was due to an independent variable. If the variability was statistically significant, the findings would indicate that the independent variable was having an effect.

We used SPSS to separate the groups for analysis, creating a grouping variable called simulation, and represented each of the three Versions as 1, 2 or 3. As would be expected, the time required to complete each respective simulation version was entered under a variable named 'Time'. Means and standard deviations were determined for each version, and by using Levene's Test of Homogeneity of Variance we verified that the assumption of homogeneity of variance was met.

A modified grounded theory approach (see Strauss and Corbin, 1998) allowed us to group track patterns as they emerged from the logged data: a preliminary reading of the tracks allowed for familiarisation of the whole data set of 36 tracks. At this stage, we suggested explanations, which was followed by a closer reading of the tracks that led to interpreting and coding into themes. To ensure rigour, the data analysis was triangulated. As two independent researchers, we reviewed the data and then reflected on and compared the themes that emerged from our independent analysis. This process helped us to develop perspectives while reducing subjectivity bias. Themes that emerged from the tracks as common or typical, resulting in what van Manen (1990) called 'control and order', allowed us to generate what Polkinghorne (1988) called 'plotlines' for the collated tracks. These plotlines inform the writing presented in this article. When reviewing the tracking data, we were particularly interested in the nature of actions and steps taken by the users, as we were interested in the nature of engagement with the different versions of the simulation. Tracking their engagement could also tell us about the influence of particular design elements, thus allowing for an evaluation of effectiveness and performance as gauged by the pre-simulation and post-simulation tests.

Findings

Our findings are based on the tracks generated by student engagement and actions when using a randomly assigned version of the titration simulation. As the simulations were allocated randomly to volunteers, six students completed a pre-survey and engaged with Version 1, while 14 students completed a pre-survey and engaged with Version 2 and 16 students completed a pre-survey and engaged with Version 3.

Our findings show that 62% of the participants thought the titration simulation was equally as interesting as a computer game, and 82% believed that science simulations were easy. Hence it could be argued that the students involved were not novices in using simulations, and perceived themselves to be efficient simulation users. Despite this, the tracks showed that, unfortunately, only one participant reached the correct response in the field CALC OK at STEP 6.

Positioning instructions and icons

An analysis of the tracks showed that if a button that controls the dropwise addition from the burette is at a more central location it increases the number of interactions with that particular control by approximately 25%. The analysis also showed that having control elements in a side position decreased the number of interactions.

Analysis showed that converting a tab menu (that slid out) into a fixed menu resulted in a decrease in the number of overall interactions, including non-productive interactions, by 30–40%.

The data collected also allows an analysis of the relationship between student responses (in terms of gender, age, computer game experience and simulation user experience) and two measures of their behaviour and activity when using the simulation:

(a) the pattern of engagement with the simulation inputs/controls,

(b) the total number of interactions between a student and the simulation.

A one-way unrelated analysis of variance (ANOVA) found that the simulation version had a significant effect on how students followed the order of the instructions ($F_{2,29}=3.69$, $p<0.05$). The extent to which students followed a recommended sequence of controls was significantly higher among the students using simulation Version 3 (M=4.24, SD=1.43), with 16 students, than for students using simulation Version 2 (M=2.85, SD=1.46), with 14 students. This was independent of age or gender. The extent to which students followed the intended sequence of controls was also higher with students using Version 3 in comparison with students using Version 1 (M=3.20, SD=1.10). However, as indicated previously, the Version 3 and Version 1 comparative finding warrants a degree of care, as there was a smaller number of students (n=6) using Version 1.

Contrary to our expectations, prior experience in playing computer games had no significant effect on how students followed the order of the instructions ($F_{1,29}=0.132$, $p=0.719$). However, prior experience in playing games had a significant effect on the number of interactions ($F_{1,29}=4.81$, $p=0.036$), with those students who indicated that they did not play computer games (n=10, M=40, SD=33) having nearly three times fewer interactions than those who indicated that they played computer games (n=21, M=129, SD=23).

The students who had previous experience (n=11, M=68, SD=64) with simulations in a lesson were on average engaged in more interactions with the simulation than those who did not (n=20, M=118, SD=129). This effect was not statistically significant. A one-way unrelated analysis of variance (ANOVA) found that prior experience in using simulations in a lesson had a significant effect on how students followed the order of the instructions ($F_{1,29}=4.21$, $p<0.05$). Perhaps, as to be expected, the students with no experience in simulation use in classrooms (n=10, M=2.82, SD=1.47) on average followed the order of the controls less efficiently than those with prior experience (n=20, M=3.95, SD=1.54).

Student perception of 'easiness' in using a simulation was found to have a significant effect on the number of interactions ($F_{2,24}=5.31$, $p<0.05$). The students who thought that it was "very easy" to use a simulation (n=2, M=336, SD=202) on average had twice as many interactions than those who thought that simulations are "easy" (n=20, M=90, SD= 97) or "not easy" (n=5, M=100, SD=85).

The analysis of data showed that age did not have any significant effect on student behaviour patterns ($F_{3,27}=0.274$, $p=0.843$).

This would suggest that regardless of whether or not the students had previously encountered the chemistry (acid-base titrations) there was no significant effect on behaviour, which would imply prior knowledge of chemistry did not have a significant effect on either the number of interactions or the order in following instructions.

Patterns of behaviour

Two of the students using Version 1 and two of the students using Version 2 did not appear to pay attention to the 'number sequence' associated with the instructions. These numbered instructions were intended to steer them and guide the decisions they made with respect to their process order. What was noticeable was that the proportion of those wrongly following numbered instructions was less for the cohort using Version 2 (simulation with pre-direction) than the cohort using Version 1, but not less than the cohort using Version 3. The difference in behaviour between the three versions showed that 10 of the 14 participants using Version 2, which is over two thirds, had chaotic behaviour patterns. In contrast, only three of the 16 participants using Version 3 had chaotic behaviour patterns, while 11 of those using simulation Version 3 (fixed position openly displayed menu and modified reading pattern) followed the steps sequentially.

Interestingly, despite having directions to steer them towards the process sequence order, only one of the participants managed to follow the steps, and 10 of the 14 students who used Version 2 either showed chaotic behaviour or only managed to complete step/instruction 2 in sequence. In addition, three of the participants using Version 2 (which provided pre-direction before they commenced using the simulation) took between 2.5 and 3 minutes to find and operate the sliding tab menu (instruction 3). There appeared to be a similar age distribution across Version 2 and Version 3, so the chaotic patterns were not due solely to age and possible prior experience. In fact, there were five first-year undergraduates using Version 2, and only one of them reached step 4 in simulation Version 2.

Conclusion

Our findings involve a small sample size, and with this come the usual caveats regarding drawing generalisations. Nevertheless, our findings suggest that simply providing instructions for students to read prior to using a simulation does not necessarily result in the students following the sequence in the simulation as designed. However, if the design is less ambiguous, for example, a 'pull out tab' menu when converted to a fixed position visible menu, the result is better engagement. It seems that additional instructions before a simulation cannot compensate for ambiguity in simulation design: despite being given directions advising them of the process sequence order, most users of the original versions (1 and 2) showed chaotic engagement behaviour tracks. In contrast, the modified Version 3, with a left-to-right and top-to-bottom aligned sequence of menu controls and a fixed visible menu, saw only one fifth of the cohort displaying chaotic behaviour, with most users following the intended sequence.

The presence of an interactive component in a simulation needs to be justified by a learning goal. While visual demonstration involving chemical laboratory tools, such as a probe or a thermometer, or a depiction of atom movement in different chemical solutions could aid learning, the interactive sliding out menu tab was a hurdle for some students who clicked multiple times on the tab control.

Our findings also show that age did not have any significant effect on the student behaviour patterns. Given that some of the participants were undergraduate degree-level students, this would suggest that regardless of whether or not they had previously encountered acid-base titrations there was no significant effect on engagement behaviour. This implies that prior knowledge of chemistry did not have a significant effect on either the number of interactions or the order in following instructions. These findings suggest that simulation design is therefore crucial if, for example, a simulation is to be used for assessment purposes. For a student may have the requisite subject content knowledge to enable them to undertake a wet-lab practical, but when they encounter a simulated version of that wet-lab practical it may be their ability to engage effectively with the technology that hinders their ability to perform to capacity.

Furthermore, given their apparent self-perception of their computer skills, they may underestimate the impact of the technological skill required to use a chemistry simulation, if they fail to pay attention to the instructions. Hence, while we would advocate that when creating simulations designers need to take care to ensure that what appears obvious to them is equally obvious to the user, we would also suggest that users, in this case students, need to start taking responsibility and understand that, while their chemistry may be sound, it may be their inability to follow instructions that affects their assessment if the assessment involves a simulation.

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Exploring the Impact of and Perceptions about Interactive, Self-Explaining Environments in Molecular-Level Animations

David A. Falvo*[1], Michael J. Urban[2] and Jerry P. Suits[3]

This mixed-method study investigates the effects of interactivity in animations of a molecular-level process and explores perceptions about the animated learning tool used. Treatments were based on principles of cognitive psychology designed to study the main effects of treatment and spatial ability and their interaction. Results with students (n=189) showed that science majors scored higher than non-science majors in retention measures (i.e., structure and function) but not in transfer. Significant main effects were found for treatment in function questions and spatial ability in structure questions. There was a significant interaction between treatment and spatial ability in structure questions. Additionally, in this study participants believed the key and the motion of ions and molecules were the most helpful parts of the animation. This study shows that students perceive the animations as being supportive of their learning, suggesting that animations do have a role in science classrooms.

Keywords: Interactive learning environments, Simulations, Visualisations

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Študija vpliva in zaznavanja interaktivnih samorazlagalnih okolij animacij molekularne ravni

David A. Falvo*, Michael J. Urban in Jerry P. Suits

Študija, izvedena po kombiniranem raziskovalnem pristopu, je ugotavljala učinke interaktivnosti v animacijah procesa na molekularni ravni in zaznave, povezane s tem animacijskim učnim orodjem. Obravnava učne vsebine je temeljila na načelih kognitivne psihologije, proučevani pa so bili glavni učinki obravnave vsebine in prostorske sposobnosti udeležencev. Rezultati učnega uspeha študentov (n = 189) kažejo, da študentje naravoslovja dosegajo višje rezultate kot študentje nenaravoslovnih ved pri preverjanju pomnjenja vsebine (npr. struktura in funkcija), ne pa tudi pri transferu znanja. Pomembni učinki so bili ugotovljeni pri obravnavi vsebine, kadar so bila vprašanja povezana s funkcijo in prostorskimi sposobnostmi, ne pa tudi pri vprašanjih, povezanih s strukturo. Pomembna povezava pa je med obravnavo vsebine in prostorskimi sposobnostmi, kadar so bila vprašanja povezana s strukturo. Udeleženci raziskave so izrazili, da sta bila legenda ter gibanje ionov in molekul del animacije, ki jim je bil najbolj v pomoč pri učenju. Študija ugotavlja, da študentje dojemajo animacije kot učinkovito podporo pri učenju, zato imajo pomembno vlogo pri pouku naravoslovja.

Ključne besede: vizualizacija, interaktivna učna okolja, simulacije

Introduction

A great deal of research has been conducted about improving students' conceptual understandings of chemistry at three different representation levels (i.e., symbolic, particle and macroscopic levels) (Johnstone, 1993; Gabel, 2005). Nurrenbern and Pickering (1987), Sawrey (1990), and Nakhleh (1993) claim that traditional instruction tends to focus on the symbolic level (see Figure 1) in lectures and the macroscopic level in the laboratory. Research has led to specific design principles for instructional multimedia (Chandler & Sweller, 1991; Mayer, 2001). Words and pictures should be used simultaneously and should be presented close to each other in space, while narration should be provided in audio format. Additionally, visualisations and symbols augment human cognitive capacities and help to convey concepts and information (Tversky, 2001).

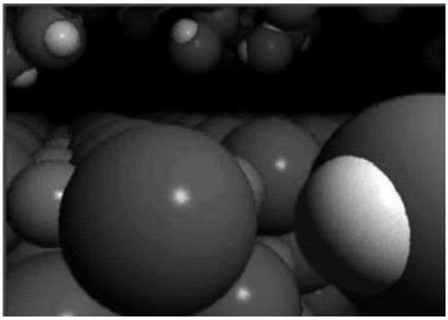

Figure 1: Image of molecules from salt dissolving in water animation.

Historically, there have been problems in the use of animations for teaching. Due to the fact that animations sometimes mislead learners, causing misunderstandings, there has been a history of caution about using these tools for teaching. Viewers often interpret movements of forms and figures in an animation as having causality, relationships and even intentions (Martin & Tversky, 2003; Tasker, 2004; Tversky, 2005). Learners assume that the colours and the shapes reflect the actual reality of the represented items, whereas the shapes and colours are, in fact, either symbolic or an idealisation of time and space relations. When effectively designed and used, these visualisations help to ensure adequate perception and comprehension in the real-world context of student learning (Kelly, 2005; Tasker, 2004; Tversky, 2001; Zacks & Tversky, 2003).

Theoretical Framework

Several studies of self-explaining environments show the effectiveness of this technique (Chi, 1996, 2000). Two studies have shown that students enhance their mental models when they engage in defining explanations of concepts and processes (Chi, 2000; Chi, DeLeeuw, Chiu, & Lavancher, 1994). In another study, researchers found that having students explain a concept using prior knowledge and cognitive reasoning improved the transfer of knowledge learning about the process (Atkinson, Renkl, & Merrill, 2003). Transfer of knowledge learning is defined as the ability to apply knowledge or skills learned in one context to another context.

In addition, several learner characteristics can affect how learners perceive and interact with animation features, and may alter the cognitive load they experience (Cook, 2006). In order to study the *spatial ability effect* on learning from an animation (Schar & Zimmermann, 2007), students were classified as "high spatial" or "low spatial" (Peters et al., 1995; Vandenberg & Kuse, 1978). High-spatial learners may learn better when visual and verbal information is presented simultaneously rather than successively. Conversely, low-spatial learners may not benefit from this design feature (Mayer & Moreno, 2003). *Prior knowledge*, a covariate in the present study, can influence the representations processed in working memory and how these representations are organised into coherent mental models (Cook, 2006; Schnotz, 2002). There is a difference between how novices and experts process information from an unfamiliar visual representation. Novices focus on the surface features of their perceptual representation, while experts link this representation to a higher level that involves conceptual understanding of the material. Experts omit irrelevant perceptual information and abstract required information from their relevant prior knowledge. Their long-term memory is organised and retrieved as well-developed schemas (Chi, Glaser, & Rees, 1982). Conversely, novices can be confused by visualisations because they lack the prior knowledge to distinguish between relevant and irrelevant information (Linn, 2003).

Research Focus

This study investigated the interactive environments in a molecular animation in a classroom setting rather than in a laboratory (Cook, 2006). The animation featured sodium chloride (salt) dissolving in water at the molecular level (Tasker et al., 2002). Students saw *structures* of solid sodium chloride, water molecules, and the structures that resulted when water molecules dissolved the ionic structures of sodium chloride crystals. They witnessed the *function* of the sodium-chloride ionic attraction that resisted this dissolving process and the opposing function where the water-ion attraction overcomes this resistance to dissolve these ions.

The research questions for this study were:

- RQ1) Does treatment (i.e., type of interactivity and the self-explaining environment used in the molecular-level animation) affect performance on the dependent variables, which are the post-test knowledge assessments?
- RQ2) Does spatial ability (high or low) affect performance on the dependent variables, which are the post-test knowledge assessments?
- RQ3) Is there a significant interaction between spatial ability and the treatment (version of the animation) that students engaged with during the study?

Method

Participants

First-year students (n=189) at a Midwestern university participated in the study. These university students were either first-year science majors or elementary education majors. The volunteers were randomly assigned to one of the treatment groups or to the control group. Participants in the qualitative component of the study came from the same pool of individuals. Five females ranging between the ages of 18 and 25 volunteered to take part in the phenomenology with semi-structured interviews (Creswell, 1998).

Instruments

Students completed a *demographic survey* about their prior experience in science, as well as providing information about their age, gender and characteristics. Their spatial ability was assessed using the Vandenberg spatial ability assessment (Peters et al.,1995; Vandenberg & Kuse, 1978). Students also took a *post-test*, which was a knowledge assessment about the topic presented in the animation (i.e., salt dissolution in water at the molecular level). This test included structure and function questions that were used as retention measures.

Research design

Prior to watching the animation of sodium chloride (salt) dissolving in water (Tasker et al., 2002), students viewed the components of the animation (e.g., see Figure 2), which were detailed on a table within the interface. The first version of the animation was basic, including just the visuals and narration, and students were able to replay the animation. In the second version, students had the option of pausing the animation at any time and were able to replay the animation if they so desired. In the third version, the animation automatically paused at selected points (i.e., segments) in order to create five short sections. At each pause point the viewer/student was prompted to either replay the previous section or to move on to the next section. The viewers also had the ability to, at any time, view any of the five sections in any order. The final version of the animation paused between each of the five sections and students were prompted to self-explain what they were seeing and thinking. They did this in a textual format. Students were allowed to revisit each section of the animation in any order.

Treatment: Four versions of an interactive/self-explaining environment

The animations used in this study illustrated the process of sodium chloride (salt) dissolving in water at the molecular level (Tasker et al., 2002). It was modified with Flash to create four different versions based on cognitive principles of instructional design. Students viewed the components of the animation (e.g., see Figure 2) before interacting with one of its four versions.

Version 1 – Control (Animation Only)

The animation played through from start to finish. Students were able to replay the animation if they so desired.

Version 2 – Pause Button.

Students had the option of pausing the animation at any time. Students were able to replay the animation if they so desired.

Version 3 – Pause Button, and Rewind and Forward Buttons.

The animation automatically paused at selected points (i.e., segments) in order to create five short sections. At each pause point, the viewer/student was prompted to either replay the previous section or to move on to the next section. The viewer/student also had the ability to, at any time, view any of the five sections in any order.

Version 4 –Pace with Self-Explaining Environment.

The animation paused between each of the five sections and students were prompted to self-explain what they were seeing and thinking. They did this in a textual format. After submitting their self-explanation, they moved to the next segment of the animation. Students were allowed to revisit each section of the animation in any order.

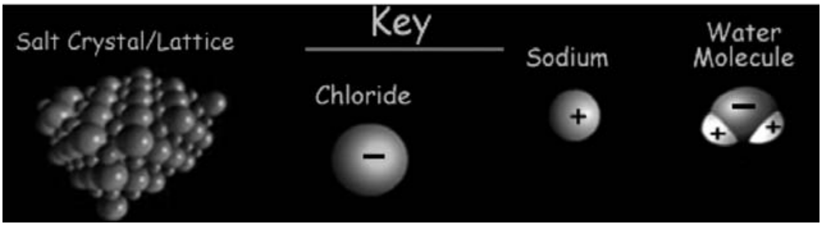

Figure 2: Table of key features in the animation.

Using SPSS, a general linear model multivariate ANCOVA was used to determine if any of the groups performed significantly better in the post-test. Using the Wilks' Lambda, the researchers explored three different aspects of the independent variables. The Wilks' Lambda (alpha = .05) measures of the proportion of variance in the combination of dependent variables that is unaccounted for by the independent variable (the grouping variable). The analyses explored the effect of treatment, spatial ability and their interaction on transfer knowledge, understanding of structural components and understanding of functional components. Data regarding whether or not participants were science majors was used as a *covariate* in the analyses. The researchers used the Tukey test as a post-hoc analysis to maintain a family-wise alpha of .05.

This research also entailed a phenomenology with semi-structured interviews (Creswell, 1998). All five interviewees planned to become elementary school teachers and ranged in age from 18 to 25. During the interviews, the researchers asked several questions to identify what participants found helpful and what they liked about the animation. Also, they were asked to consider their diagrammatic sketch from the previous study to establish a sense of what they understood, or to let them enhance their sketch by making it more understandable.

Results

Using SPSS, the MANCOVA test (Table 1) produced significant results for the model on the structure and function retention dependent variables but not for the transfer variable. For the covariant (science or non-science majors), overall the science majors did better on structure (p = .005) and function (p = .016) dependent variables (Table 2).

Table 1: MANCOVA tests of between-subjects effects.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	structure	109.310 [(a)]	8	13.664	4.496	.000
	function	18.095 [(b)]	8	2.262	3.032	.003
	transfer	4.646 [(c)]	8	.581	.840	.569
Course (co-variable)	structure	24.456	1	24.456	8.048	.005
	function	4.383	1	4.383	5.875	.016
	transfer	.793	1	.793	1.147	.286
Treatment	structure	7.007	3	2.336	.769	.513
	function	11.674	3	3.891	5.217	.002
	transfer	1.321	3	.440	.637	.592
Spatial ability (high or low)	structure	25.073	1	25.073	8.251	.005
	function	.167	1	.167	.223	.637
	transfer	.172	1	.172	.249	.619
Treatment * Spatial ability	structure	56.124	3	18.708	6.156	.001
	function	.846	3	.282	.378	.769
	transfer	2.568	3	.856	1.238	.297
Error	structure	547.002	180	3.039		
	function	134.265	180	.746		
	transfer	124.436	180	.691		
Total	structure	2651.000	189			
	function	953.000	189			
	transfer	762.500	189			

Variance explained by model for each dependent variable:

[(a)] R^2 = .167 (Adjusted R^2= .130)

[(b)] R^2 = .119 (Adjusted R^2 = .080)

[(c)] R^2 = .036 (Adjusted R^2 = -.007)

Table 2: Significant effects of the students' course of study, the co-variable, on the structure (p = .005) and function (p = .016) dependent variables.

Tukey HSD

Course of study (co-variable)	N	Dependent variables Structure Mean	 Function Mean.
Science majors course	115	3.543 **A**	2.183 **A**
Non-science majors course	74	2.790 **B**	1.865 **B**
Sig. Alpha = .05 Level	*p* =	.005	.016
Means with the same letter (A or B) are not significantly different			

High-spatial students only scored higher than low-spatial students (p= .005) in structural questions (Table 3). There was a significant interaction effect between treatment group and spatial ability (p = .001), as depicted in the graph in Figure 3.

Table 3: Significant effects of treatment groups on the function dependent variable (p = .002).

Tukey HSD

		Function	
Treatment group	N	Mean	Std Dev
1: Control	48	2.333 **A**	0.808
3: Pause and Pace	48	2.271 **A**	0.818
4: Self-explain	45	1.867 **AB**	1.014
2: Pause	48	1.750 **B**	0.838
Alpha = .05			
Means with the same letter (**A** or **B**) are not significantly different			

Table 4: Significant effects of spatial ability on the structure dependent variable (p = .005).

Tukey HSD

		Structure	
Spatial ability	N	Mean	Std Dev
High spatial ability	78	3.653 **A**	2.067
Low spatial ability	111	2.964 **B**	1.666
Alpha = .05			
Means with the same letter (**A** or **B**) are not significantly different			

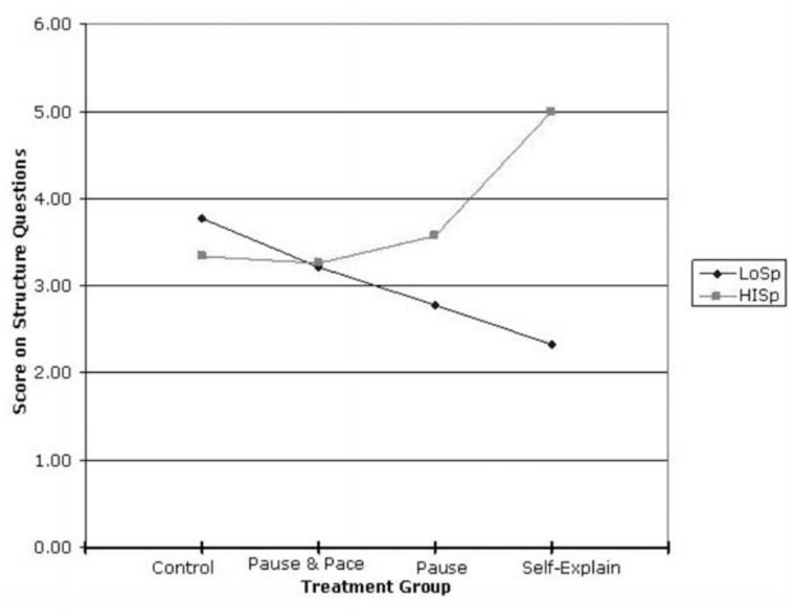

Figure 3: Significant interaction between treatment and spatial ability (p = 0.001) on the structure dependent variable.

The qualitative results in this study show that most participants believed the key and motion of ions and molecules were the most helpful parts of the animation. Students perceived the animations as being supportive of their learning and believed that animations have a role in the modern science classroom. When questioned about what they remembered about the animation they had viewed prior to seeing it again, three categories emerged relating to what students remembered about the animation: molecules, chemistry and other. Three themes emerged related to what students felt was helpful: a key, movement and audio. Of the five participants, three specifically mentioned the benefit of a key.

Many of the things that the participants liked about the animation overlapped with things they found to be helpful. For instance, in describing things they liked, two participants used the words "movement" and seeing the molecules "up close" (respectively). Another stated that the animation was "easier to understand than just somebody telling you what was going on" and "more entertaining." Adding more audio to the animation was the primary suggestion. According to Mautone and Mayer (2001), when narration emphasises key steps and associated links, students "learn more deeply" from a multimedia explanation (p. 387). One person indicated that the animation should also have audio on the first viewing, not just the last. Another person suggested using audio to define the charges, as in a verbal key (the animation narrator does this while the molecules are moving but it is not a separate entity, such as an introduction). One person wanted to see arrows pointing to the molecules identifying them within the animation.

At the end of each interview, participants were asked how they felt the animation would affect them as educators. One participant responded to this question with, "it's an interesting way to incorporate technology in the classroom…it's always nice for students to hear something from another point of view." Three others intimated the importance of visualisation to elementary students. Some literature would seem to agree. Tversky (2001) says that visualisations enhance cognitive competence. One of the participants said, "…kids are stimulated more by visuals…I think they'll be able to relate to this way of teaching more than writing stuff on a chalkboard or lecturing or seeing things in a book." This statement is also significant because she had only heard the narration, and had not actually seen the animation. She stated, "…I think it's a good thing. I think it gives a visual and that helps a lot of people learn, to see an actual visual that is a representation, instead of just hearing it."

Discussion

Science majors outscored non-science majors in both retention measures, i.e., structure and function questions in the post-test (Table 2). The science majors had been briefly exposed to salts dissolving in water previously; however, their prior knowledge was limited to mostly symbolic representations in lectures and mostly hands-on experiences with the dissolving process in the laboratory portion of their course. Conversely, the non-science majors had little or no prior knowledge of this process. This lack of prior knowledge was probably responsible for the latter group's inability to organise the verbal and visual information from the animation into coherent mental models (Cook, 2006; Schnotz, 2002). These students focused on salient surface features, such as the colour of the spheres used to represent ions and molecules (i.e., structural features) rather than the relative positions of the structures, which gives meaning to chemists as domain experts. Apparently, the three treatment versions designed to reduce extrinsic cognitive load for the non-science majors could not overcome the intrinsic load imposed by the interrelated set of ionic and molecular structures and their associated functions (Chandler & Sweller, 1991). The lack of significant difference between science and non-science majors on transfer measures suggests that the former were also not able to form coherent mental models. Perhaps the science majors' unfamiliarity with the medium (they were not accustomed to viewing molecular animations) was a factor in preventing them from developing a conceptual understanding of the dissolving process.

Treatment produced a significant difference in the function-dependent variable (Table 3). The fact that none of the three treatments designed to reduce extrinsic load outperformed the control group in function questions suggests that the extrinsic load for students in these treatments remained relatively high. Hence, they were unable to free the cognitive capacity needed to process intrinsic loads of the functions involved in the dissolving process. The control and pause-and-pace groups both outperformed the pause group, which suggests that the latter may have experienced an extra extrinsic load when students had to decide when to "pause" as they were viewing a molecular process that had too many unfamiliar stimuli.

Another explanation for these results is that the control version went rather quickly, so students may have replayed the animation several times in order to understand it. The pause button version slowed the animation somewhat, so students may not have replayed it multiple times. For this group, the animations likely caused extrinsic cognitive load because students had to think about and decide when and where to pause the animation. Confirming Mayer's (2003) findings, pace (breaking the animation into five segments) helped students with function questions. Students wondering why something happened in the animation were able to go back and view the segment of the animation again to help them understand. The control group did just as well because students viewed the animation multiple times. However, because students did not have a basic cognitive mental model for the function components, they were not able to capitalise on self-explaining the concepts. It is likely that students in the self-explaining treatment group did not repeat the segments of the animation. Repeated viewing of the animation, or sections of it, may have helped students better understand functional components of the concept. This is an area worthy of further research.

The study found a spatial ability effect where high spatial ability students outperformed their low-ability counterparts in structure questions only (Table 4). As shown in Figure 3, the self-explanation treatment greatly enhanced the performance of high spatial ability students while it inhibited the learning of low spatial ability students. These results are in contrast to those found with the control group, which produced essentially no differences between high-spatial and low-spatial groups. This implies that the self-explanation treatment reduced the extrinsic cognitive load of high-spatial learners such that they were able to free cognitive capacity to provide a greater intrinsic load, which allowed development of a coherent mental model for the structures shown in the animation.

Thus, high-spatial learners gained from the simultaneous presentation of visual representations in the animation and verbal representations in the narration apparently because they had time to reflect upon their nascent mental model during the pause after each of the five segments. However, segmentation into meaningful stages was insufficient to allow the formation of mental models because students viewing Version 3 (pause-and-pace, which also had segmentation) did not outperform the control group. As predicted by self-explanation literature (Chi, 1996, 2000; Sweller, van Merrienboer, & Paas, 1998), the self-explanation group was *prompted* several times during the animation to explain the segment they had just viewed. This prompting allowed them to develop a deeper understanding of the domain (i.e., the dynamic molecular process) by forming a meaningful mental model for each segment. Since experts had decided where to place these pauses between meaningful segments, the high-spatial learners were apparently making the link between their perceptual representations and their conceptual representations of the dissolving process.

In sharp contrast to the above, the low-spatial learners did not benefit from the pause or self-explain treatments apparently because they could not simultaneously process the verbal/narration and visual/animation information given in each segment. When asked to explain what they had just viewed, they may have experienced an extra extrinsic cognitive load in which their knowledge was incomplete and their self-confidence may have been eroded. Meanwhile, low-spatial learners in the control group, who outperformed their counterparts in the self-explain group, may have replayed the entire animation several times in order to try to integrate verbal and visual information. The discontinuous animation experienced by low-spatial learners in the other two treatment groups must have also adversely affected their understanding of the molecular process; that is, the pause button (see Figure 4) for low-spatial learners in these treatment groups may have induced an extrinsic cognitive load relative to the low-spatial learners in the control group, who experienced the continuous-play animation.

In terms of the qualitative data, the primary finding of this study is that students felt the key was a critical component of the animation. Many liked the fact that there was movement in the animation, such as "zooming in on" and seeing "up close" through multiple visual angles. Colour and audio narration were also described as things the participants liked. Few dislikes were described. The comments included seeing the key before viewing the animation, and having labels that pointed to objects being described in the animation. Most of the students interviewed indicated that they would have liked more audio narration; for example, during the first run through the animation and during the presentation of the key. Several participants stated that they did not foresee ever being in a situation where they would use this type of animation in elementary education.

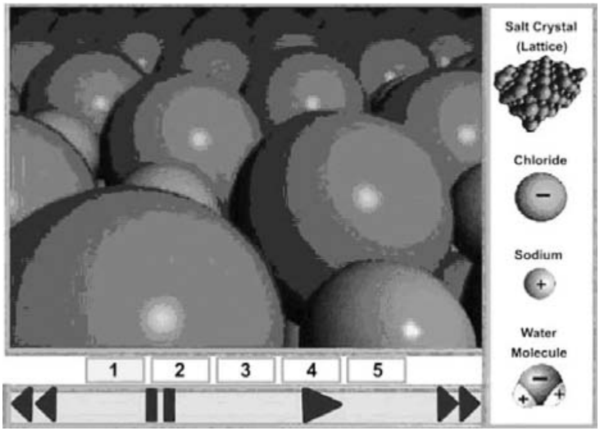

Figure 4: Screen shot of the interface design of the animation including controls.

Conclusions

High-spatial learners need to pause after each meaningful segment and self-explain what they have just experienced in terms of visual and verbal information so they can develop effective mental models (Chi et al., 1982). Conversely, low-spatial learners may need animations that they can "play" continuously until they get an intuitive feel for the process being represented. Perhaps after several replays, they could try to explain to another student what they appear to understand in a more "holistic and flowing" manner rather than in a play-by-play manner filled with explicit details that could overload cognitive capacity. However, these results have to be interpreted cautiously because the effects were certainly not widespread over both retention and transfer measures. More research is needed to determine how to best structure and use these innovative tools. If animations are to live up to their promise to improve teaching and learning in science, researchers must continue to address how to best integrate these tools into science classrooms.

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Visualisation of Animals by Children: How Do They See Birds?

Sue Dale Tunnicliffe[1]

Children learn to recognise animals from their earliest years through actual sightings in their own observations of their world, but also through second-hand representations in various forms of media. Young learners begin with a template specimen to which they refer when they see another animal that resembles it, naming the animal accordingly. Gradually, they learn to distinguish members of the subordinate category – bird in the case of the present paper – into subcategories. Accessing their mental model through drawings is one means of discerning their interpretation of both phyla and species. If children of increasing ages are studied, a rationale for the understanding of a such concepts may be forthcoming. The present study investigated children from 6 years to 14 years though interviews, as well as through the drawings on which the paper focuses. As children mature, they observe more and more details about the birds that they see, thus increasing their knowledge not from school but from their own observations outside school.

Keywords: Children's drawings, Children's understanding of birds

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Vizualizacija živali pri otrocih: kako vidijo ptiče?

Sue Dale Tunnicliffe

Otroci se od majhnega učijo prepoznavati živali, ko jih dejansko vidijo, kadar opazujejo svet okrog sebe oz. v različnih medijih. Ti mladi učenci najprej razvijejo vzorčni model neke živali, ki si ga prikličejo, ko vidijo podobno žival in jo poimenujejo po tem modelu. Postopoma se otroci naučijo razvrščati predstavnike te kategorije organizmov – v tem primeru ptiče – v podkategorije. Ena izmed možnosti raziskovanja otrokove interpretacije debla in vrste kot taksonomske kategorije je uporaba risbe, s katerimi otroci prikažejo svoje mentalne modele. Z raziskovanjem mentalnih modelov različno starih učencev lahko ugotovimo, kako se s starostjo učencev razvijajo tovrstni pojmi. Ta raziskava je zajela učence, stare od 6 do 14 let, podatki pa so bili zbrani z intervjuji in risbami učencev, na katere se prispevek osredinja. Ko učenci odraščajo, opazijo vse več podrobnosti v povezavi s ptiči, kar vpliva na boljše znanje o teh organizmih, to pa ni povezano z znanjem, pridobljenim v šoli, ampak z lastnim opazovanjem zunaj šole.

Ključne besede: risbe učencev, razumevanje pojmov o ptičih

Introduction

Children see animals in their everyday lives. They notice them in the real world and often in the media, both electronic and paper forms, as well as in representations in household items such as wallpaper for children and soft toys (Tunnicliffe, Gatt, Agius, & Pizzuto, 2008). When they see live animals they identify striking features of their anatomy and behaviour, whether they are observed in everyday life (Patrick & Tunnicliffe, 2011) or in a zoo or field centre, for instance (Tunnicliffe, 2000). When looking at animals as exhibits (Tunnicliffe, Lucas, & Osborne, 1997) children remark out loud about the salient features of the animals they see, such as a leg, a shape, bits that stick out and colour, as well as any behaviours observed at the time. Thus, from their earliest years, children gain knowledge and experience of the animals in the everyday environment where the children live and attend school. Indeed, this knowledge is not necessarily gained from formal education (Tunnicliffe & Reiss, 1999a, 2001), which may serve simply to amplify and extend existing knowledge. However, pupils in English state schools are taught about the basic grouping of organisms in their formal schooling. A useful point to bear in mind when considering formal teaching strategies for children to learn more about animals is that school science generally assumes that for any scientific issue there is a single valid scientific conception. Other ideas that do not agree with the accepted conception are alternative conceptions, and are often called misconceptions. Driver, Squires, Rushworth and Wood-Robinson (1994) refer to personal knowledge that has been acquired through the child's own life experiences, both real and virtual, as alternative conceptions.

Theoretical background

Visualisation in science education embraces many different aspects of the concept, ranging from mental models and their formation, which are considered central to science learning, to recognising 2D and 3D representations, which can show aspects of the learner's grasp of concepts (Gilbert, 2005). As Gilbert points out, the interpretation of visualisation varies between researchers. In the present paper, visualisation is considered as visual imagery shown through drawings but in conjunction with personal knowledge construction expressed in words about the phenomenon, in this case the bird that is commonly referred to as a pigeon.

Looking after animals influences children's understanding of the biology of animals (Inagaki, 1990). The knowledge of animals held by children has been explored by several researchers. For instance, Hantano and Inagaki (1997) showed that children's biological understanding is acquired in their early years through daily experiences. Amongst the variety of animals with which children come into contact, birds have been a frequent species of study. Randler (2009) found that the knowledge of a variety of species of bird increased with age in primary children after a particular method of teaching. Prokop, Kubalto and Francovicova (2008) investigated children's concepts about birds, investigating the knowledge and attitudes of Slovak pupils about this vertebrate class. Birds are not regarded as dangerous. Hens and chickens were the only birds mentioned in Cardak's study (Cardak, 2009) of Turkish students' ideas about dangerous animals, and these were only referred to three times, which is an insignificant number. However, Prokop and Tunnicliffe (2010) found that children knew more about unpopular animals, and in English society pigeons are certainly unpopular.

A great deal has been written about visualisation in science education, but it is confined to the physical sciences and not the natural sciences (Gilbert, 2005). When teachers or researchers ask subjects about their understandings of anything, subjects respond by presenting representations (Bruner, 1964). Such representations may be words or mathematical symbols, drawings, physical constructions or even gestures. When these representations are made in the public domain for anyone to observe they may be referred to as expressed models (Buckley, Boulter, & Gilbert, 1997). The only way for a researcher to understand the mental model held by the subjects, in this case children, is to observe one or more of their expressed models. Although there are limitations to studying drawings executed by children – their inability to draw what they want to due to a lack of skill, and what seems like unintelligible marks to the researcher often being able to be explained by the child in an interview – drawings are nonetheless still a means of accessing mental models.

Drawing is easier than writing for many children, particularly very young children, and making representations on paper is a stage in the development of a normal child, when they are in the iconic mode and progress to the symbolic mode (Bradford, 2012). The basic hypothesis of Luquet, (1921, cited by Krampen, 1991) is that, in the development of drawings executed by young children, there is a gradual tendency toward realism. Thus, the final aim of drawing would be a realistic translation of the visual properties of objects into graphics.

According to Luquet, in drawings children do not directly transmit the characteristics of objects, that is, they do not simply copy them, but rather they put on paper the features of internal models of objects that they observe. Luquet proposed five phases in drawing development: (1) *Scribbling* (typical at ages 2–3 years); (2) *Fortuitous realism* (the discovery of similarities between certain features of scribbles and objects in reality, which begins to emerge at ages 3–4 years); (3) *Failed realism* (synthetic incapacity, as seen in drawings by children of 4–5 years of age); (4) *Intellectual realism* (the child draws what is known about reality, a stage that is generally from 5–8 years); (5) *Visual realism* (in this stage, which occurs between ages 8–12, the child draws what is visible only from a certain point of view in reality, i.e., from a certain perspective).

Symington, Boundy, Radford and Walton (1981) proposed three stages, which involve children acquiring both the skill and the conceptual basis to produce recognisable pictures. First of all, they proposed a scribbling phase, when children are able to actually hold a writing implement and successfully mark the paper. In this phase, the child produces scribbles that to them may represent the organism that they have been requested to draw, but to others hardly bears any resemblance to the animal. Developing from this is scribble symbolism, with the output on paper being used more as a symbol of the child's idea of the object than to show what it is really like. In this stage, the salient features such as the head and torso of a human are drawn. The last phase, visual realism, is where the object and the picture bear a closer and more detailed resemblance.

The mental models drawn upon by the child when drawing an animal are representations of an object, or an event, that are formed by the process of modelling, as pointed out by Duit and Glynn (1996), who state that the process of forming and constructing models is a mental activity of an individual or group. The models are personal and unique, based on the child's own knowledge of the phenomenon, that is, animals seen in the everyday environment, museums, nature parks and zoos, as well as in representations in books and electronic media, in contrast to conceptual knowledge acquired through formal and informal education. The conceptual knowledge of the formal curriculum includes the taxonomic position of the species, its criteria attributes, and the intension and extension of the species. There is, however, a relationship between the mental model, the animal or human viewed (the trigger or real object) and what the child says.

Brooks (2009) suggests that through visualisation and expression through the representation of ideas, the essence that children have understood is focused in consciousness early on; thus, she suggests that a drawing is an externalisation of a concept or idea. Drawings are products of the drawer's imagination (Reiss, Boulter, & Tunnicliffe, 2007) and memory as expressed models (Gilbert & Boulter, 2000). As Brooks (2009) points out, drawings and visualisations can also help young children to shift from everyday or spontaneous concepts to more scientific concepts. Their construction also enables children to come to terms with spatial visualisations, interpretations, orientations and relations, and Brooks claims that when children are able to create visual representations of their ideas they are more able to work at an achieved cognitive level. There is, of course, always the proviso that the children must be capable of achieving the technical and manipulative skills of drawing. Personal experience of interviewing children with their previously constructed drawing indicates that knowledge of the subject, e.g., the organs in the human body, can be greater than the understanding indicated by the drawing, as although the child constructing the drawing may have found a particular feature too difficult to represent, he or she was able to describe the phenomenon in an interview (Tunnicliffe, Boulter, & Reiss, 2011).

Figure 1: A self-portrait by Luc aged 4.

Influenced by what they see, children abstract out the salient features of the human form, as in the self-portrait by a four-year-old boy (Figure 1). In the early years, children have an innate desire to draw even before they can articulate a description. For these young children, drawing is an effective form of conjunction, provided that whoever reads the drawing can interpret that which they draw. The 'tadpole man' of Figure 1 is a frequently cited example of this, where children draw a body, a head and stick limbs.

It is already known that knowledge of the internal organs of humans and other organisms can, to a certain extent, be elicited through analysing drawings constructed by children of differing and increasing ages according to a protocol. This includes work on the skeletons and internal organs of vertebrates (Tunnicliffe and Reiss, 1999b; Prokop et al., 2008).

Research questions

The research questions were:

1) What do children know about a common everyday species of bird, the pigeon, (*Columba palumbus*)?
2) How do children visualise a common species in words and in a drawing?
3) To what extent are drawings of birds similar when drawn by children of increasing age, and is there an identifiable progression in skill of representation?

Answers to these particular questions were sought in data collected from a wider study of six frequently found organisms and two natural phenomena in the everyday environment.

Method

Participants and location

School children drawn from five classes of Year 1 children (aged 5–6 years), Year 4 children (aged 9–10 years) and Year 9 children (aged 3–15 years) were interviewed and asked to draw an environmental scenario that included birds. This work was carried out as part of a larger study (Tunnicliffe et al., 2011). The children attended a variety of schools in Southern England, including London, and were from a range of ethnic and first-language backgrounds.

Instruments

The cues used to initiate dialogues prior to a visit to a field site, zoo, museum or field centre were either a black and white reduced-image line drawing, a colour photograph with a context, or the word 'pigeon'. After the field visit, dialogues were initiated by using a word – in the case of the present paper, the word 'pigeon'.

Research design

The children were interviewed and cued to talk about what they knew about pigeons. The interviews were transcribed and analysed according to a rubric of levels of organisation (see Tunnicliffe et al., 2011). The drawings of the environment including all of the items discussed were collected after the final interviews and analysed by the author using a 'look re-look' process to identify the features of the birds that were portrayed. Details of the particular criteria used are given with the findings below.

Results

The data collected revealed that older pupils in secondary school had more specific knowledge of pigeon characteristics, and that this knowledge was based on observations of behaviours rather than on formal teaching. Many of the older children reported that pigeons are kind of a grey colour. One respondent remarked, '*They have silver and green wings and are shiny and that you can get white pigeons which are called doves. Erm, they are birds they fly.*'

Biological information supplied by the pupils was not always accurate; they demonstrated biological knowledge from their own observations and listed what they regarded as the criteria attributes of 'pigeonness', by which they meant birds in general. The features of birds exemplified by pigeons are beaks, colour, wings and legs, with older pupils also mentioning feathers. These are the features represented in the drawings constructed by the pupils.

When interviewed with the one of the cues – a colour photograph, a black and white drawing or the word (Pigeon) – the children talked about the specific behaviour of pigeons that they had observed as part of the essence of being a pigeon, as well as basic anatomical features. The justification for allocating pigeon to a bird was given by one six-year-old boy as, *'Because its got wings and two legs, a pigeon is a bird, err. They are quite big and have got err.... grey feathers.'* An older primary school pupil said, *'I normally see them flying around the sky in my back garden.'* Another remarked, *'...it's a bird because it flies.'* A girl who attended a Year 9 class reported, "*Um, when they make a noise it's like a too-wit–too-woo sort of noise, a bit like an owl. Um, there are loads of them in London.*' Another of the secondary school children informed us, '…*they make nests. They like to sit on top of our school roof, they reproduce, they can fly.*' A six-year-old boy talked about pigeon racing characteristics and how if a male and female pigeon were put together they mated. In her interview, a fourteen-year-old girl was asked what they ate; she responded, '…*worms they are supposed to but they don't.*' The same girl went on to remark about a specific behaviour – flying – and then talked about a characteristic anatomical feature of birds, '… *well they are quite aerodynamic so that when they fly they are smooth, urhm, they have got beaks for clinging onto tree branches and claws. That's about it.*'

In terms of human influences, a number of children were familiar with the uses of pigeons in our society, such as pigeon racing, and had obtained knowledge from their family. A ten-year-old boy attending Year 5 reported that his father had kept pigeons, not for racing but for sending notes, while a six-year-old boy attending Year 1 reported, *'I know all about pigeons 'cos my grand-dad's got them.'*

Pigeons were regarded as urban inhabitants. A ten-year-old boy attending Year 5 reported that he saw pigeons in lots of places, including at football matches in London, where they walked on the pitch. Other children of all ages talked about seeing pigeons in their local town congregating outside the fast-food shops to eat any potato chips and other food debris on the pavement. Some older pupils did, however, know about the behaviour of worm-eating birds in stamping on the ground to simulate the vibration of rain, to which earthworms respond by emerging from their burrows.

Children had noticed pigeons themselves in their local town, as one Year 5 pupil reported: '*It's got wings and two legs and likes nicking your food up town when you go to buy fish and chips. When you drop one they always go running to it!'* Other human- pigeon interactions mentioned included pigeons eating food scraps in towns, and the fact that they sometimes carry disease. The secondary pupils (Year 9, older than 11 years) held the perception that pigeons were dirty; *'rats of the air'* was the phrase used by one girl.

Representing pigeons – the drawings

The pigeon is represented in several ways in drawings, and there are a range of ways in which children depict reality (Reiss et al., 2007). The first basis of the analysis of the drawings obtained, undertaken through inspection, was the layout, an exhibit-type picture representation with the organisms placed with a relationship to one another, together representing where they may be found naturally. For instance, trees were always drawn coming from the ground where the grass was drawn. A few children drew isolated organisms with no link to one another. Secondly, the way in which the pigeon was represented was examined. The representations included as a symbolic 'V' shape, just an outline of a bird, an outline with basic features, and an artistic realistic image. Thirdly, there was an assessment of whether the pupils had shown any behaviours of the pigeon in their drawing. Finally, a record was made of whether more than one pigeon had been drawn and whether another type of bird was included in the drawing.

Figure 2: Drawn by a Year 9 pupil, the picture shows the iconic 'V' drawn to represent birds, as well as an outline drawing of a bird flying.

In the expressed model of pigeons revealed through the drawings, only solitary birds were drawn. The bird was not placed in the urban context in which the children reported seeing the birds for themselves and was shown exhibiting behaviour such as flying, sitting in a tree or standing on the ground. Interestingly, although ecology teaching in England stresses food chains and food webs, feeding relationships were not depicted in the drawings.

The data presented in Figure 2 reveal how the pigeon is depicted, whether the bird is presented as part of a drawing, even if the image drawn shows a known behaviour such as walking or flying but with no relationship to another object. Young children abstract out salient features – a round body, two legs, two wings, a head and a beak – similar to the abstraction of main features shown by child's drawing of a human in Figure 1.

Table 1: Analysis of drawings of natural objects, one of which was a pigeon, by 24 pupils, with some pupils drawing several representations.

Feature in drawing	**Year 1 (6 years)**	**Year 5 (10 years)**	**Year 9 (14 years)**	TOTAL
Drawing black and white	6	0	7	13
Drawing in colour	0	6	5	11
List drawing	3	1	7	11
Exhibit style	3	5	5	13
Symbolic representation			2	2
Outline	1	1		2
Basic features, beak, legs, body, wings	1	6	10	17
Artistic image			1	1
Behaviour shown, e.g., walking, flying	7	8	17	32
One plus drawn	1	1	3	5
No bird	2			
Other type of bird, e.g., duck	3			3

Alternatively, the target object is shown as an exhibit-type illustration in the manner of a natural history diorama, including all of the specimens being studied and shown with some type of relationship between them, as well as portraying their behaviours known to the pupil, such as a tree growing upright, grass on the ground near the tree and the bird being portrayed involved in a known behaviour.

Table 2: The behaviours shown in the drawings of the pupils.

Behaviours illustrated	**Year 1 (6 years)**	**Year 5 (10 years)**	**Year 9 (14 years)**	TOTAL
Walking on ground	3	6	12	21
Flying	2	1	5	8
Sitting in tree	2	1	0	3
Total	7	8	17	32
Five drawings had more than one bird	1	1		

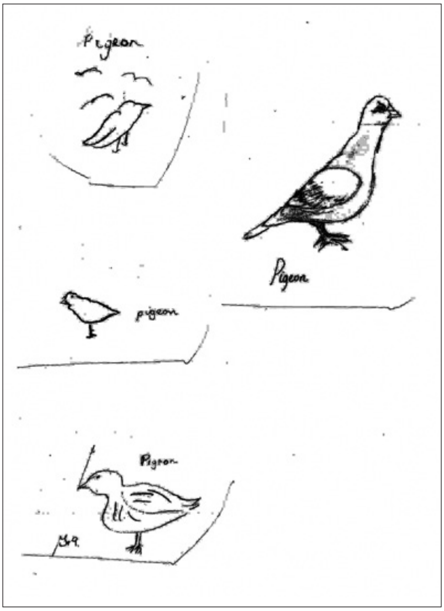

Figure 3: The range of ways in which pigeons were represented. Three levels of interpretation – outline, symbols and realism.

An example of behaviour recalled from having been told or seen in cartoons was the fact that birds eat worms, a behaviour that was cited by some children. Some interviewees mentioned this phenomenon but did not draw it. The iconic representation of a pigeon ranged from a simple 'V' symbol (Figure 2), through a basic outline, to an outline with a more accurate representational drawing showing the criteria attributes that the pupils considered to be those of 'birdness', e.g., two legs, a slightly torpedo-shaped body, a beak at the front of the head, and wings, similar to how the 'humaneness' features are shown in Figure 1. Indeed, these attributes are those to which the pupils referred in their interviews when describing how they would know that a pigeon is a pigeon. Such features are, in fact, bird characteristics of the super ordinate category bird, and are not specific to 'pigeon'. For example, one of the Year 5 pupils said, '*It has wings, a beak and legs.*' Pupils did not mention feathers in their list of criteria features, nor, with the exception of the artistic rendering in one drawing (Figure 3), did they draw them. Two Year 5 pupils used colour. The drawings illustrated basic anatomical defining features, such as two wings, two legs, feathers and a beak, as well as behaviour such as flying or walking on the ground (or water!!!). Year 9 pupils executed drawings using colour and were the interviewees who composed more realistic drawings (although not all of them, by any means). This phenomenon was noted by Luquet (1927 translated 2001), who commented that adults are committed to visual realism whereas children are proponents of a cerebral analytic process.

A few drawings showed the bird exhibiting behaviour such as flying, walking on the ground or sitting in a tree, while a few offered two levels of interpretation: symbols and basic features (Figure 3).

Occasionally, an artistic rendering was made as if drawn from life (Figure 3). Several other fourteen-year-old pupils, not included in the target sample, drew almost photographic likenesses of a bird in a detailed drawing forming a pictorial composition. We did not interview the pupils with their drawings, so we were unable to explore certain features, such as the object in the two birds drawn in Figure 4. However, several of the pupils talked about pigeon babies and eggs, so the circular object drawn in the body of the birds could be those images. A few pupils drew individual drawings of the objects represented in absolute isolation with no context, and one drew his pigeon next to a pond.

Other drawings placed the objects in a rural or garden setting, without buildings, with some interrelationship between the objects (Reiss et al., 2007). Two of the Year 1 pupils drew two birds, one in a tree and one on the ground, while two Year 5 pupils also depicted two birds. One drawing by a Year 1 child showed a bird looking rather like the Concorde aircraft on the ground, and another bird, possibly a representation of a duck, walking on the surface of a pond.

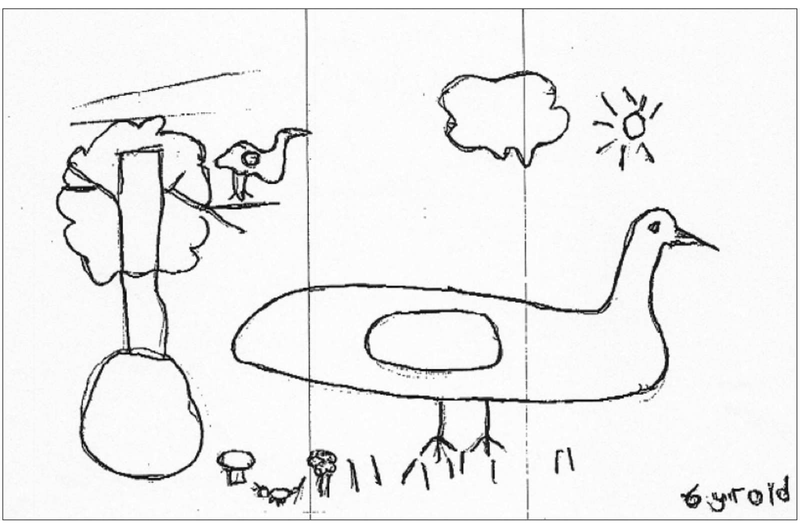

Figure 4: Birds with "eggs" inside.

The majority of the Year 9 drawings illustrated the objects separately in the manner of a key. Three drawings were executed as a composition. Several of the birds were depicted artistically in a lifelike manner. Apart from the artistic representations drawn by a fourteen-year-old, the drawings were simple outlines.

The results show that a study of everyday animals based on interviews and drawings (done on separate occasions) reveals not only biological knowledge but also widespread social and some cultural beliefs and understandings. The systems analysis revealed personal experiences that were important to the speaker in the form of narrative, connected with the probe word. The most detail was given about the anatomical features of the pigeon, such as feathers and a beak. The pupils knew that pigeons live on the ground or in trees and that they can fly. Mainly older pupils were conversant with the public understanding of the pest and vermin role of pigeons in our society, while some pupils had knowledge of the use of pigeons by humans, although the eating of pigeons was not mentioned.

Discussion

Children thus have a considerable knowledge of the living world immediately around them from personal first-hand observations, both real and virtual. We know that children explain phenomena in other animals by using themselves as their reference (Carey, 1985). In the present study, the pupils extrapolated from their knowledge of themselves, or the behaviour of birds they knew, to the species under consideration. These ideas may be reinforced by cartoons and popular stories, such as the concept that all birds eat worms in the interview mentioned above. The children in the studies reported here had made observations and had experiences of many of the objects through activities with their families and school. School grounds emerged as an important influence in a number of the interviews. In research in which children were interviewed in the presence of whole, live plant specimens and preserved, whole, animal specimens (Tunnicliffe & Reiss, 1999a, 1999b), it was also evident that home influences were most important in providing the children with their understandings of the organisms. The schools described in the present paper are in suburban settings, and it would be interesting to compare the results obtained with those from schools in urban and rural settings. From an early age, children are able to abstract the salient features that make up the concept ‘bird’ from their own observations, both real and second hand through cartoons and other media.

Perhaps more attention should be paid to producing both formal and informal school activities that draw on this rich knowledge of how humans interact with the natural world. School grounds could be used for such observations. The revealed importance of gardens and school grounds suggests that teachers should be alert to the interests that many pupils still have in horticulture and gardening.

Most pupils described where the pigeon they were asked about had been seen, and thus could be found. The places mentioned were generally places of social interaction for human beings in their everyday lives, not isolated wildernesses. They included parks, gardens, school fields and football pitches, streets or squares in towns, their homes and their immediate neighbourhood. Venues do not need to be to distant pristine habitats in order to be memorable to children. In fact, linking school science, especially science for preschool and primary children (3-11 years in England), with pupils' memories of local places may be an important way to start to focus on biological learning, either inside the classroom or when planning visits, rather than focusing on exotic mega fauna with a visit to the zoos and creating rain forest simulations in classrooms, as so many English schools do. One striking conclusion from the research reported here is the importance of popular myth in children's knowledge. The myths that children knew regarding many of the objects had clearly been strongly influenced by books, TV programmes and cartoons of birds pulling up worms, a behaviour that pigeons do not display.

Conclusions

Educators need to be aware of the separate domains used by learners in interpreting biological phenomena. Moreover, the educator often introduces pupils to organisms by using a key word, thus eliciting the pupil's existing mental model. This is not necessarily the same for all pupils, as it depends on their interest and experiences influenced by their immediate sociocultural environment, as well as by the natural world. It may also reveal understandings gained from everyday experiences and from children's media and myths, as well as popular public understanding about the phenomenon, in this case a commonly seen animal. Thus, if meaningful learning by pupils is to be constructed, biological concepts cannot be taught in isolation from an awareness and knowledge of other influences that contribute to a child's understanding. As children develop, they become more involved in feelings, and, it seems, in the possible influences of themselves and others on their environment.

The data obtained in the present study indicate that specific species are not taught in English schools. General shared features of birds are acquired from everyday observations in the early years: beaks, two wings, two legs and feathers, as well as characteristic behaviours, such as flying and eating food debris. Specialist knowledge, such as carrier pigeons, racing pigeons and breeding birds, was acquired first hand from another persons, often a family member.

What is clear from these studies is that school teaching and the learning opportunities provided at school do not have as greater influence on how children understand objects in the natural environment as we might perhaps think, especially in the case of younger children. Both formal and informal educators could learn by observing, speaking with and listening to pupils about what they experience in their own worlds, what interests them and what aspects of the natural world they have learnt about through books and other media and influences. Such baseline knowledge of learners should be the basis for teaching these ideas, and should form foundations on which teachers and curriculum planners formulate curricula and assessments.

Note: Part of this paper was presented orally at the BERA conference at the Institute of Education, London in September 2007.

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Biographical note

Sue Dale Tunnicliffe, Dr., an expert on children in zoos and has published widely, she is graduated in zoology and has specialised in education, a qualified teacher, holds a PhD from King's College. Now a researcher/part time lecturer at the Institute of Education, she set up and run an advisory team in primary science and technology, then was Head of Education at the Zoological Society of London and has worked part time in a historical museum as science adviser and as an education consultant at the BBC. She has worked as a researcher and lecturer at Cambridge and Winchester Universities.

Building Partner Cooperation between Teachers and Parents

Barbara Šteh*[1] and Jana Kalin[2]

This paper presents the goals of teacher-parent cooperation, various potential models for establishing mutual cooperation, and the conditions required to achieve quality interactive cooperation. The partnership model is highlighted as an optimal model of interactive cooperation between teachers and parents, as it includes the distribution of expertise and control with the purpose of ensuring optimal education for children. It enables the creation of an interactive working relationship in which all of those involved are respected and recognised in their efforts to achieve common goals.

The second part presents the findings of an empirical study carried out on a representative sample of Slovene primary schools. Teachers (N = 467) and parents (N = 1,690) were asked to express their opinions about the need for mutual cooperation, their view of each other when fulfilling their respective roles, and where they perceive the main obstacles to mutual cooperation. It became evident that teachers and parents have doubts about each other's competence. This does not form a solid base on which to establish and build the necessary partner relationship, and along with it mutual cooperation. Yet both groups to a large extent agree that teacher-parent cooperation is both necessary and useful. This gives rise to the question as to how to ensure that schools adopt policies promoting opportunities for better understanding, for building quality mutual relations and for parents to become more actively involved.

Keywords: Models of mutual cooperation, Obstacles to cooperation, Partnership model, Teachers and parents

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Graditev partnerskega sodelovanja med učitelji in starši

Barbara Šteh* in Jana Kalin

V prispevku so predstavljeni cilji sodelovanja med učitelji in starši, različni mogoči modeli vzpostavljanja medsebojnega sodelovanja in pogoji za doseganje kakovostnega medsebojnega sodelovanja. Izpostavljen je partnerski model kot optimalni model medsebojnega sodelovanja med učitelji in starši, saj vključuje delitev ekspertnosti in nadzora z namenom zagotoviti optimalno izobraževanje za otroke. Omogoča ustvarjanje medsebojnega delovnega odnosa, v katerem se spoštuje in upošteva vse vpletene v prizadevanju za doseganje skupnih ciljev. V drugem delu predstavljamo izsledke empirične študije, izvedene na reprezentativnem vzorcu slovenskih osnovnih šol. Učitelje (N = 467) in starše (N = 1.690) smo spraševali o njihovem mnenju o potrebnosti medsebojnega sodelovanja, o tem, kakšen je njihov pogled drug na drugega pri izpolnjevanju svojih vlog, ter v čem vidijo poglavitne ovire za medsebojno sodelovanje. Pokazalo se je, da učitelji in starši dvomijo o kompetentnosti drug drugega, kar ne predstavlja dobre osnove za vzpostavljanje partnerskega odnosa in sodelovanje drug z drugim. Oboji pa se v veliki meri strinjajo, da je sodelovanje učiteljev in staršev potrebno in koristno. Zastavlja se torej vprašanje, kako v okviru šole zagotoviti možnosti za boljše medsebojno razumevanje, graditev kakovostnih medosebnih odnosov in aktivnejše vključevanje staršev.

Ključne besede: modeli medsebojnega sodelovanja, ovire za sodelovaje, partnerski model, učitelji in starši

Introduction

Numerous studies confirm that it is important to attract parents to co-operation with the school and teachers, in order to comprehensively encourage the child's development (Burden, 1995; Gonzalez-DeHass, Willems, & Doan Holbein, 2005; Henderson & Berla, 1994; Jordan, Orozco, & Averett, 2001; Lewis, Kim, & Bey, 2011; Pomerantz, Moorman, & Litwack, 2007; Soo-Yin, 2003). Referring to various studies, Hornby (2000), for example, points out the numerous benefits on different levels resulting from the active involvement of parents in school life. These benefits include improving parents' opinions of teachers and schools, and also of their pupils, resulting in a reduction in negative behaviour amongst pupils, thus achieving a more appropriate school atmosphere. These positive changes foster improved communication between parents and children, leading to a rise in parents' expectations of their children, etc., which in turn brings about an improvement in pupils' learning habits and a corresponding improvement in academic achievements. Researchers have confirmed that the overall involvement of parents represents a positive contribution to learning and the learning achievements of pupils (Hendeson & Berla, 1994; Hoover-Dempsey & Sandler, 1997 in Gonzalez-DeHass et al., 2005). These studies prove that there is a close relationship between the involvement of parents and pupils' learning achievement, their wellbeing, their attendance at school, their views, their homework assignments, their school marks and their educational aspirations. This is also linked to higher learning achievements of pupils, the time spent on their homework, a more favourable attitude towards school and a lower number of pupils who quit school ("dropouts").

All of these effects naturally differ according to the degree and quality of parents' direct involvement, but certain effects are already present if parents are regularly informed of their child's progress (Swap, 1993 in Hornby, 2000). Woolfolk (2002) points out that teachers can create a more positive classroom environment, allowing them to dedicate more time to teaching, when they share the same expectations as parents and when both sides support each other. The goals of mutual cooperation between teachers and parents are thus evident. However, this gives rise to the question as to what form such cooperation should take, and how to establish and develop it.

Models of establishing teacher-parent relationships

Teachers may assume very diverse attitudes towards parents, ranging from seeing them as a problem, as competitors, as too vulnerable and needing help, through the belief that a professional distance has to be kept towards parents, and finally to the opinion that they can provide a valued support in educating their children and can act as good collaborators. The key factor for fruitful cooperation is whether the teacher can engage in dialogue with parents on an equal basis and see them as partners in mutual educational activities and problem solving. On the other hand, the teacher may place parents in an inferior position, where parents mainly have to be taught, or in a superior role, where teachers feel that they need to apologise for and justify their own actions. In establishing and maintaining equal roles or a partnership between teachers and parents, it is worth keeping in mind that both teachers and parents are experts: teachers on education and parents on their own children (Hornby, 2000). It is only possible to cooperate creatively if parents' powers and competence are recognised and taken into account (O'Callaghan, 1993 in Čačinovič-Vogrinčič, 1999). We often underestimate the importance of information that parents can reveal to us about their children, while, on the other hand, we as teachers can disclose to parents how their child performs in the school environment not only at the cognitive but also at the emotional and social level. In addition, teachers should be competent in creating an optimal and encouraging learning environment that eases and encourages the learning process. The views of both groups can, of course, be subjective, due to the position from which they enter the relationship. Parents are, as can be expected, usually "advocates" for their own children (Henry, 1996 in Čačinovič-Vogrinčič, 1999); they are emotionally bound to their own child and have difficulty accepting certain "truths" about him or her. Nor are teachers as independent in their own views as it would seem at the first sight, as they are part of a system that poses its own demands and value criteria, which can also limit the teacher's perspectives (for example, their image of a "good, obedient pupil", and of a "good teacher" who sticks to the rules). If parents and teachers manage to trust one another and to be frank with one another, they can view pupils, each other and their problems in a more realistic light, thus contributing to their more efficient cooperation.

Two extremes of parent-teacher relationships are pointed out above: on the one hand, there is a relationship with the necessary submission of one party – usually parents, but sometimes also teachers – while, on the other hand, there is a partnership. Approaches to establishing relationships between teachers and parents can be differentiated and classified ranging from those that downplay the involvement and active role of parents to those that emphasise it. Hornby (2000) lists the following models of establishing teacher-parent relationships, defined by varied sets of assumptions, goals and strategies:

1. In the *protective model* (Swap, 1993 in Hornby, 2000), it is important

to avoid conflicts between teachers and parents. This is best achieved through a total separation of teaching and parenting. Education is the school's and teachers' task, and parent involvement can be perceived as a disturbing interference. Swap (1993 in Hornby, 2000) considers this to be the most common model of teacher-parent relationship.

2. In the *expert model* (Cunningham & Davis, 1985 in Hornby, 2000), teachers consider themselves as experts in all aspects of the development and education of children. The role of parents is to accept information and instructions regarding their children, and they are pushed into a completely submissive role and into dependence. Parents are not supposed to question teachers' decisions and thus lose confidence in their own competence, while, at the same time, teachers with such an attitude are not admitted to the rich source of information that parents have about their children and often overlook important problems or abilities of pupils.
3. In the *transmission model* (Swap, 1993 in Hornby, 2000), teachers still consider themselves as the major source of expertise, but they accept that parents can play an important role in enhancing their child's progress. They present particular measures to parents and expect them to carry them out.
4. In the *curricular enrichment model* (Swap, 1993 in Hornby, 2000), the parents' contribution can enrich the curriculum and thus significantly enhance a school's educational goals. It is a good opportunity for teachers and parents to learn from each other. The problem is that parents thus enter the area of teaching and many teachers find this threatening.
5. In the *consumer model* (Cunningham & Davis, 1985 in Hornby, 2000), parents have control over decisions. The teachers' role is to present all of the relevant information and available possibilities to parents and to help them choose the optimal course of action. This eliminates the fear that parents are pushed into a dependent role, but the fact that teachers lose their professional responsibility is problematic in the same way as the opposite situation where teachers are seen as experts on all aspects of the child's development. Establishing teacher-parent cooperation based on this model is undoubtedly present in the Slovene environment, and it would be interesting to investigate how often teachers are pushed into a role in which they have to carry out requirements imposed by others (ranging from detailed instructions on various rules to parents' requirements regarding issues such as whether a teacher is permitted to punish a pupil, to give home work, etc.), as such cases take away teachers' professional autonomy.

6. The most suitable model of teacher-parent cooperation is the *partnership model*, as it includes the sharing of expertise and control with a view to ensuring the optimal education for children, to which both teachers and parents contribute. Naturally, it is not possible to establish such a partnership if there is no mutual respect between teachers and parents. Teachers and parents should listen to each other's opinions and take them into account. A partnership occurs when there is mutual planning and sharing of responsibilities, as well as a certain long-lasting involvement and the carrying out of particular activities. Hornby (2000) points out four key elements of such partnership:
   - two-way communication,
   - mutual support,
   - common decision-making,
   - encouraging learning.

Within the framework of a partner relationship, some authors particularly stress the importance of establishing a work union or working relationship that may be denoted as participative efforts to attain common goals. Typically, such a relationship is oriented towards both "here and now" and towards the future, it focuses on the positive and optimistic, it is a meeting point of equal parties who respect and recognise the competences of others involved, as well as recognising sources of power, beliefs, knowledge and experience that have been effective in the past (Čačinovič Vogrinčič, Kobal, Mešl, & Možina, 2005, Shazer, 1985 boath in Šteh & Mrvar, 2011a).

The *partnership model* is often perceived as the most suitable model for developing constructive parent involvement (Esler, Godber, & Christenson, 2000; Hornby, 2000), as teachers also take parents' needs into account and are aware of various manners in which parents can contribute to the development and education of their children. However, this does not mean that this model is the most suitable for all situations. It is important to be flexible and to adapt the approach to parents' characteristics.

When planning cooperation with parents, it is naturally important that we are aware of obstacles in parents. "Research conducted in the 1980s and 1990s searching for variables related to differences in parental involvement focused on deficiencies of parents" (Edwards & Warin, 1999 in Lewis et al., 2011, p. 221). In the 21st century, especially under the influence of studies by Epstein, the focus has shifted from studying parents' deficiencies and reasons why they are unable to cooperate with school to critically analysing the existing practice and improving school practice towards promoting "active parental participation", since the school oversees several relevant resources, particularly in the area of adequate teacher training (Lewis et al., 2011).

Conditions of efficient cooperation between teachers and parents

It is important for every school to encourage and facilitate teacher–parent partnerships that increase the involvement of parents and their participation in encouraging the social, emotional and intellectual development of their child (Children's Defence Foundation 2000 in Soo-Yin, 2003). School, parents and the community should be aware of their interaction and should together create a vision and understand the role of individual factors in relation to the roles of others. Such cooperation is necessary to ensure the support and assistance that every child needs to succeed at school.

For this purpose, it is important to create an appropriate school culture determined by the values, attitudes and behavioural patterns typical of the school as a whole (Rutter, Maughan, Mortimore, Ouston, & Smith, 1980 in Bečaj, 1999). These factors to a great extent determine the establishment of mutual relationships and the methods of communication between teachers and parents. In this way, they also determine the characteristics of the mutual cooperation model. It is important to note that the school becomes and remains a so-called "learning organisation", for which discussions, creativity, activity, participation, cooperation, flexibility, acceptance of risk, evaluation, reflection and a developmental attitude are typical (Holly & Southworth, 1989). The development of school as an institution cannot be imagined without the development of a culture of participation among the employees, learning with each other and one from another, in constant connection and cooperation between teachers, parents and the wider social community. For teachers, both appropriate beliefs and qualifications are necessary to achieve these purposes.

In relation to this, we have to be constantly aware that parents are a very heterogeneous group of individuals and that we have to adapt our activities and methods of cooperation accordingly (Šteh & Mrvar, 2011b). The more varied forms of cooperation and involvement we offer parents, the more chance there is of attracting them to cooperate. Parents' involvement and cooperation also differ in relation to their characteristics, needs and qualifications (Kalin & Šteh, 2008). Moreover, it is important that teachers are sensitive to obstacles (objective and subjective) that may prevent parents from becoming more actively involved, and that they endeavour to remove such obstacles. "Parental participation in school, including participation by minority parents, increases when teachers demonstrate more receptive and supportive attitudes toward parental participation at school and actually reach out to parents to bring them into the school" (Desimone, Finn-Stevenson, & Henrich, 2000, Deslandes & Bertrand, 2005, Epstein, 1984, 1986, Kohl, Lengua, & McMahom, 2000 all in Lewis et al., 2011, p. 221). It is particularly worth making an effort at the beginning and establishing two-way communication, in order for parents and teachers to have an opportunity to get to know each other, to clarify their expectations and to further build their relationship. A teacher has various methods available, from sending personal messages or "class letters" to all parents, making telephone calls, using pupils as carriers of messages, to feedback regarding the pupil's learning achievement, monthly descriptions of the pupil's progress, etc. Parents need to feel that teachers are not indifferent towards their child and that parents' support is both welcome and required in the education of their children (Lewis et al., 2011).

The more teachers try to intensify parents' involvement and to establish a partnership relationship, the more participation, communication and organisation skills teachers have to master. Hornby (2000) points out the following:

- mastering the basic skills of listening and counselling,
- skills of assertive communication,
- organisational and communicational skills to maintain contacts with parents (meetings, e-mails, telephone calls, etc.),
- skills in involving parents in the educational programmes of their children (in organising learning, in adjusting learning, in encouraging motivation, in building self-respect, etc.)
- skills of leading a group, so that various group meetings for parents can be organised.

At this point, we would particularly highlight listening and assertive skills. Usually teachers have well-developed skills for transmitting information and explaining, but their listening skills are not always as advanced. It is probable that they see themselves more in the role of a speaker, a transmitter of information and advice, rather than in the role of a listener. It is crucial for them to become aware of how important it is for them to be able to listen – to their pupils and colleagues and, of course, to parents. Ineffective communication may occur because we do not listen to the person to whom we are speaking and are absorbed in our own thoughts, because we selectively receive information sent by the interlocutor and interpret it according to our own expectations and anticipated prejudices, according to our relation towards the sender of the message or towards its content, etc.; we can also unconsciously convey unintended messages (Jaques, 2000). When parents were asked about how they would want teachers to change, a very frequent answer was simply that they should listen better (Hornby, 2000). In listening it is not enough only to hear, but to be ready to understand, which is a psychological and not merely a physiological process.

On the other hand, teachers often have to face criticism, aggressive behaviour and unrealistic demands. In such circumstances, it is important that teachers are able to express their feelings, needs and demands clearly, peacefully and without any hostility – they need to be assertive in their behaviour (Hornby, 2000; Woolfolk, 2002). The most demanding task for them may be to distinguish between situations in which they primarily have to lend an ear and situations where they have to make clear demands. Actually, they need both types of skills in their mutual cooperation with colleagues, pupils and parents: whenever they discuss measures and tasks of the one group or another, when they plan common activities and during the process of mutual problem solving.

In order to acquire participation and communication skills, teachers need additional training. However, training for these skills is not enough alone; teachers' willingness to understand and help is essential for the success of their work with pupils and parents (Kottler & Kottler, 2001), together with their trust in the ability of pupils and parents to find their own powers or to additionally develop their problem-solving competence (O'Callaghan, 1993, Saleebey, 1997 boath in Čačinovič-Vogrinčič, 1999). If we highlight a partner or working relationship as our goal, it is crucial to know whether teachers are prepared for such a relationship, whether they believe their efforts will be fruitful and whether they are genuine, respectful and emphatic in their interpersonal communication (Hornby, 2000). Still, teachers are not all-powerful, and it is right that pupils and parents take their own share of responsibility for effective learning and mutual cooperation.

The purpose of the research

Within the goal-oriented research project "Levers of successful cooperation between the school and home: modern solutions and perspectives" (Kalin et al., 2008) we were interested in how teachers and parents evaluate mutual cooperation and what the key problems of such cooperation are. We devoted special attention to identifying drivers of change – the improvement of cooperation between school and family, teachers and parents. In this paper, we will limit our discussion to the part of the findings linked to the following research questions:

1. What are teachers' and parents' attitudes to the benefits and necessity of mutual cooperation?
2. What do teachers themselves think of the view parents have of them?

How do parents view teachers? Do they see them as experts on education or not?

3. To what extent do teachers and parents agree that today parents know how to be parents, and that they need additional education in parenting and family education problems?
4. What obstacles to mutual cooperation are highlighted by teachers and by parents?
5. Are there any statistically significant differences between teachers and parents in answering the above questions?
6. Are there statistically significant differences between parents in answering the above questions depending on their level of education?

Method

We used a descriptive and causal-non-experimental method of pedagogical research. The basic population included all of the primary schools in Slovenia (N = 448), which were further divided into two strongly distinguished strata, namely urban (N = 237) and non-urban schools (N = 211). The strata were conceived as independent groups within the entire basic group. We then randomly selected 20 urban and 20 non-urban primary schools from these strata, thus forming a random sample at the first level. At each school, we selected 'a' classes of the 3rd grade, 5th/6th grade and 9th grade and distributed questionnaires to the pupils' parents. We received 1,690[3] completed questionnaires from parents. We intended to include in the research all of the class teachers from all 40 schools from the random sample, and we sent 713 questionnaires to these teachers. We received 467 (65.5%) completed questionnaires.

Anonymity was ensured to both teachers and parents. Questionnaires for teachers and parents contained multiple choice questions, scales and open-ended questions. We sent the questionnaires to schools by post in November 2007, and we received the completed questionnaires towards the end of December 2007 and in the beginning of January 2008. The data was processed with the SPSS statistical package, using descriptive statistical and the hi-square test, or the Kullback 2Î test in cases where the expected count was less than five in more than 20% of the boxes of the contingency table.

3 2,302 questionnaires were sent to parents of all of the pupils attending the 'a' classes of the third, fifth or sixth and ninth grade at the selected schools. The data about how many questionnaires were distributed to parents is not available.

Results and discussion

Teachers' and parents' attitudes to the benefits and necessity of mutual cooperation

Teachers and parents show statistically significant differences in their attitudes towards the statement that the cooperation of school and parents is necessary and useful (2Ī = 173.369; df = 4, a = 0.000). 76.8% of teachers and 43.1% of parents absolutely agree that such cooperation is necessary and useful. Teachers express a high degree of agreement with the statement, while parents show a little more caution. These conclusions may be a challenge for teachers and parents to justify and word the purpose and usefulness of the cooperation between school and parents. If teachers alone predominantly agree with such cooperation, it does not mean that it will, in fact, be useful and effective. Most parents are aware that their cooperation with school is important; however, they may need support in clarifying their role in order to predominantly express complete agreement with the necessity and usefulness of mutual cooperation. Epstein (1990 in Hornby, 2000) establishes that most parents are interested in the education of their children but fail to know what schools expect of them and how they can contribute to the schooling of their children.

Table 1: Teachers' and parents' attitudes to the benefits and necessity of mutual cooperation.

		Cooperation of school and parents is necessary and useful.					
		I absolutely disagree	I do not agree	I partially agree	I agree	I absolutely agree	Total
Parents	f	1	8	114	789	692	1604
	f%	.1	.5	7.1	49.2	43.1	100.0
Teachers	f	0	0	6	98	345	449
	f%	.0	.0	1.3	21.8	76.8	100.0
Total	f	1	8	120	887	1037	2053
	f%	.0	.4	5.8	43.2	50.5	100.0

Parents show a statistically significant difference (c2 = 20.915; g = 8, a = 0.007) in their attitudes to the statement that the cooperation of school and parents is useful, in function of the achieved level of education. Their most frequent answer is that they agree with the statement. The answer "I absolutely agree" was the most frequently chosen (46.4%) by parents with the highest level of education and the least frequently (38.9%) by parents with primary and vocational education. The answer that they partially agree was chosen by 9.8%

of parents with the lowest level of education and by 5.8% of parents with the highest education. In our case, parents with higher education show a much greater extent of agreement with the statement that the cooperation of parents and school is necessary and useful. This may be because most of them see their role in a clearer way and feel more competent to help their children with their school obligations.

Table 2: Parents' attitudes to the benefits and necessity of mutual cooperation in relation to their education.

			Cooperation of school and parents is necessary and useful.					
			I absolutely disagree	I do not agree	I partially agree	I agree	I absolutely agree	Total
Parents' education	PS +VS	f	1	6	44	222	174	447
		f%	.2	1.3	9.8	49.7	38.9	100.0
	SS	f	0	2	45	353	314	714
		f%	.0	.3	6.3	49.4	44.0	100.0
	Coll.+Univ. and above	f	0	0	24	198	192	414
		f%	.0	.0	5.8	47.8	46.4	100.0
	Total	f	1	8	113	773	680	1575
		f%	.1	.5	7.2	49.1	43.2	100.0

Legend: PS = Primary school; VS = Vocational school; SS = Secondary school; Coll. = College; Univ. = University

Compared to the share of parents with lower levels of education, it is evident that a larger share of parents with higher education are of the opinion that their cooperation with school is very sensible. Teachers need to be aware that in their work with less educated parents it will more often be necessary to help these parents to develop an awareness of their role in supporting the academic development of their children. Many of these parents probably even feel incompetent to help their children in learning, and they themselves need guidance in finding ways to help their children at home. Sometimes they only need some encouragement in order to talk with their children about their schoolwork and to show interest in their work, as this is an important way of participation. These are strategies of developing a "positive parenting role" (Lewis et al., 2011).

Do parents see teachers as experts?

The majority of teachers who responded (81.2%) thought that parents see them as experts who know how to provide knowledge and to educate, while only 8.3% of teachers think that parents see them as people who know how to provide knowledge, but not how to educate. There is a high share of respondents who answered “Other” (10.5%), where teachers stated answers such “I don’t know”, “I can’t decide”, etc.

Table 3: Teachers’ opinions on how parents see them.

What do you think is the parents’ view of you?	f	f%
You are experts who know how to provide knowledge and to educate	362	81.2
You know how to provide knowledge, but not how to educate	37	8.3
Other	47	10.5
Total	446	100.0

As expected, parents were much more critical in their evaluation of teachers. Teachers were probably inclined to give the desired answers, since it is expected from them to both provide knowledge and educate, and as experts in both they also want to be seen as such by parents. Parents’ answers differed in a statistically significant degree from teachers’ answers (c2 = 1.849; df = 3, p = 0.000, n = 2063).

Table 4: Parents’ opinions about teachers.

What is your general opinion of teachers?	f	f%
They are experts who know how to provide knowledge and educate	806	49.8
They know how to provide knowledge, but not how to educate	678	41.9
They are not experts	18	1.1
Other	115	7.1
Total	1617	100.0

Only half of parents (49.8%) judge that teachers are experts who know how to provide knowledge and educate. As many as 41.9% of parents believe that teachers know how to provide knowledge, but not how to educate. The category Other includes mostly responses from parents (7.1%) that teachers differ a lot amongst themselves, and that such a judgment cannot be generalised to all teachers, since some are also excellent educators, while others do not get involved in education, which consequently gives rise to the question as to whether they have chosen the right profession.

Parents’ opinions about teachers show a statistically significant difference in relation to their achieved education (c2 = 52.02; df = 6, p = 0.000, n = 1586).

Table 5: Parents' opinions about teachers in relation to their education.

			What is your general opinion of teachers?				
			They are experts	They know how to provide knowledge, but not how to educate	They are not experts	Other	Total
Parents' education	PS +VS	f	283	168	8	12	471
		f%	60.1	35.7	1.7	2.5	100.0
	SS	f	319	331	9	54	713
		f%	44.7	46.4	1.3	7.6	100.0
	Coll.+Univ. and above	f	193	161	1	47	402
		f%	48.0	40.0	0.2	11.7	100.0
	Total	f	795	660	18	113	1586
		f%	50.1	41.6	1.1	7.1	100.0

Legend: PS = Primary school; VS = Vocational school; SS = Secondary school; Coll. = College; Univ. = University

From Table 5, it is evident that parents with primary and vocational education form the majority (60.1%) of those who consider that teachers are experts for providing knowledge and education, while parents with at least secondary or further education indicate to an increasing degree that teachers are only experts for providing knowledge or that there are vast differences among them (category Other). For parents with the lowest education level, teachers in most cases still represent experts for providing knowledge and education, while parents with higher levels of education more often doubt teachers' expertise and are much more critical in their opinion of teachers. Above all, parents with the highest levels of education most often additionally explain their opinions and point out that teachers are varied and that it is difficult to give a single opinion of all teachers. We assume that among the parents with higher levels of education who are critical towards teachers, there are more of those who would try to push a teacher into a subordinate role in terms of exercising the so-called consumer model of teacher-parent cooperation (in Hornby, 2000). In such cases, it is important that teachers are backed up by the school management, who should support teachers' autonomy and offer them opportunities to continue their training for working with parents and their professional development. On the other hand, among parents with lower education levels there are more of those who need teachers' assistance in developing their full powers.

Do parents know how to be parents?

In establishing a partnership it is important for parents to competently fulfil their role, to believe in their own powers, and also for teachers to attribute them this power (O'Callaghan, 1993 in Čačinovič-Vogrinčič, 1999). We asked parents and teachers about the extent to which they agree with the statement that parents know how to be parents today, and in their answers to this question both groups show statistically significant differences ($\chi 2 = 2.24$; $df = 4$, $p = 0.000$, $n = 2062$).

Table 6: Presentation of parents' and teachers' attitudes towards the question as to whether parents today know how to be parents.

		Parents today know how to be parents.					
		I absolutely disagree	I don't agree	I partially agree	I agree	I absolutely agree	Total
Parents	f	20	76	651	663	198	1608
	f%	1.2	4.7	40.5	41.2	12.3	100.0
Teachers	f	4	52	329	67	2	454
	f%	0.9	11.5	72.5	14.8	0.4	100.0
Total	f	24	128	980	730	200	2062
	f%	1.2	6.2	47.5	35.4	9.7	100.0

More than half of parents (53.5%) agree or absolutely agree with the statement that parents know how to be parents, while 40.5% partially agree with the statement and only a small percentage of parents do not agree or do not agree at all (5.9%). Teachers are much more critical towards parents in responding to this question, as a mere 15.2% of teachers agree with the statement, while 72.5% of teachers partially agree and 12.4% do not agree with the statement. Teachers therefore doubt to a greater extent whether parents today can be parents – that they are experts in the area of their own child's development and education.

It is interesting to note that parents with higher education are much more critical towards themselves, as the share of parents partially agreeing with the statement grows with the increased level of their education (33.8% to 46.2% of the most educated parents), while the share of those who agree or absolutely agree with the statement (60.1% to 46.7% of the most educated parents) decreases.[4] These differences among parents are statistically significant ($\chi 2$ = 18.57; df = 8, p = 0.017, n = 1578).

In relation to this, we asked parents and teachers about the extent to which they agree with the statement that parents need to be additionally educated about parenting and problems of family education. In their response to this question, both groups show statistically significant differences ($\chi 2$ = 1.98; df = 4, p = 0.000, n = 2057). More than a third of parents (36.1%) expressed agreement with the statement that they need additional education on problems of family education, while a similar proportion of parents (35.3%) partly agreed with the statement and less than a third of parents (28.6%) expressed their disagreement. In contrast, as many as 65.1% of teachers believe that parents need additional family-related education, while approximately one third (32.3%) partially agree with the statement and only 2.7% of teachers do not agree. Teachers are therefore inclined to believe that parents need additional parenting-related education and, from their point of view, planning of cooperation forms such as "school for parents" enriches cooperation between the school and home. According to the results, more than a third of parents would be responsive to such an offer, while other parents are not convinced or have different expectations of school. This again shows that with such a proposal teachers can primarily approach parents with higher education.

The results therefore show that both groups express a degree of mutual doubt in the other's competence, and it is certainly difficult to build a partnership and fruitful cooperation on such grounds (Hornby, 2000).

Obstacles to cooperation between teachers and parents

Both teachers and parents are largely convinced that there are no obstacles to their cooperation. However, this opinion is more prevalent among parents than among teachers. Teachers more frequently stated that the main obstacle was the overburdening of parents; the next was laying the blame for everything on the teachers (stated by parents), and finally poor familiarity with each other. Parents agreed that the reason for obstacles is poor familiarity with

4 Due to extensive text, the results are not in the form of a table in the case of this research question and for another two research questions presented later in which we ask about differences between teachers' and parents' answers and in parents' answers in relation to their achieved education level. Nevertheless, detailed descriptions are given, as the results significantly complement and shed light on various views of teachers and parents or parents in relation to their achieved education level.

each other, and they also placed stress on being overburdened. It is noteworthy that teachers refer to the overburdening of parents as one of the obstacles more often than parents. Probably they do not have a proper insight into what limits their mutual cooperation, and this is also indicated by the answer that they are limited by poor familiarity with each other. Both teachers and parents did not suppose that bad experiences in regard to their mutual cooperation might be the reason for obstacles – they mentioned it in an almost negligible percentage.

Table 7: What is the biggest obstacle to cooperation between teachers and parents?

	Teachers		Parents	
	f	f%	f	f%
Blaming teachers/parents	64	**14.4**	69	4.4
Underestimation by parents/teachers	18	4.1	46	2.9
Not knowing each other well	60	**13.5**	269	**17.1**
Overburdening of teachers	15	3.4	82	5.2
Overburdening of parents	120	**27.0**	161	**10.3**
Bad experiences with parents/teachers	1	0.2	16	1.0
Criticising teachers/children all the time	15	3.4	65	4.1
There are no obstacles	151	**34.0**	862	**54.9**
Total	444	100	1570	100

In mentioning obstacles to cooperation, parents' level of education is shown to be an important factor ($\chi2 = 31.97$; $df = 14$, $p = 0.004$). More parents with a higher level of education feel that there are obstacles to their cooperation with teachers (51.0% of parents with a university degree and 60.4% of parents with elementary education said that there were no obstacles). Poor familiarity with each other is given as a reason significantly less frequently among parents with elementary education (11.7%) than among parents with higher education (21%). Criticising their children all the time is most frequently cited as a reason by parents with elementary education (5.1%) and the least frequent by parents with a high level of education (1.8%). The findings again indicate the fact the parents are very diverse, with different expectations and needs, and consequently need to be attracted to and involved in cooperation with school or teachers in various ways.

Conclusion

Numerous authors who have studied cooperation between teachers and parents stress the importance of such cooperation for pupils' achievement and quality of schooling (for example, Burden, 1995; Gonzalez-DeHass et al., 2005; Henderson & Berla, 1994; Hornby, 2000; Jordan et al., 2001; Lewis et al., 2011; Pomerantz et al., 2007; Soo-Yin, 2003). Teachers and parents in our research agree that mutual cooperation is useful and necessary. Among teachers there is a much bigger share of those who absolutely agree with the statement, while among parents those with a higher level of education show a larger extent of agreement with the statement.

The research showed that building positive mutual relationships between teachers and parents is a prerequisite for improving successful cooperation. This inevitably presupposes compliance with basic principles of mutual respect and acceptance of the individual differences, interests and needs of various groups of parents. Both teachers and parents express doubt in each other's competence. Although the majority of teachers (81.2%) are of the opinion that parents see them as people who know how to present knowledge and to educate, only half of parents (49.8%) agree with this. For most parents with the lowest education level, teachers still represent an authority in both areas, schooling and education, while parents with higher levels of education are more critical in their opinions. More than half of parents (53.5%) agree or absolutely agree with the statement that parents know how to be parents. Regarding this question, parents with higher education are more self-critical, as more of them only partially agree with the statement compared with parents who are less educated. Parents with higher education are also more inclined to accept additional education on parenthood and the problems of family education. Similar to those parents who are more critical towards teachers, the latter are even more critical towards parents, as only 15.2% of teachers agree with the statement that today parents know how to be parents. Teachers' and parents' opinions of each other therefore represent one of the key obstacles to increasing the quality of mutual cooperation, since mutual respect and recognition is a prerequisite to building a partnership relation (Hornby, 2000).

Among the obstacles to mutual cooperation, teachers most frequently mention the overburdening of parents, laying the blame on teachers and not knowing each other well enough, while parents primarily highlight poor familiarity with each other and their own overburdening. Therefore, when planning mutual cooperation, each particular school should look for methods with which they can attract parents with their varied characteristics and provide possibilities for improved mutual understanding. Lewis et al. (2011) point out that parents' participation increases when teachers demonstrate more receptive and supportive attitudes toward parental participation, when they show parents that they care about their child and that parents' help is welcome and needed.

The proposals of our research are strongly in line with findings of previous studies (Kalin, 2001, 2004); namely, that in the field of teacher-parent cooperation it is necessary to build a culture of dialogue and problem solving in an atmosphere of respect and acceptance of the differing characteristics of both teachers and parents, and that it is necessary to constantly reflect on the current situation and on this basis develop higher quality and more efficient ways of cooperation between schools and parents. An essential starting point of any culture of good cooperation is allowing each other freedom and autonomy, awareness of interdependence and common goals. These are the very foundations on which it is possible to build a culture of partnership in cooperation between teachers and parents.

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Biographical note

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Valenčič Zuljan, M. and Janez, V. (Eds.) (2010). Facilitating Effective Student Learning through Teacher Research and Innovation. Ljubljana: University of Ljubljana, Faculty of Education. 490 p., ISBN 978-961-253-051-8.

Reviewed by Barica Marentič Požarnik

The 20 studies in this monograph, contributed by authors from 13 different countries and four continents (most of the contributions are the result of collaboration between two or more authors), represent a variety of topics, methodological approaches and findings. The studies span the whole school system – from primary through secondary to higher education, (such as the contribution by Maciejowska and Frankowicz, which describes a model of introducing innovative approaches into the teaching of university professors); they range from small-scale innovations, limited to one lecture room (such as the experiment of Rodicio and Sanchez on improving explanations) to nationwide attempts to innovate teaching (such as fostering teacher innovation in chemistry teaching in Tailand, by Coll et al.).

In spite of their differences, all of the studies start from a common, very important question: How can innovations brought about by teacher research lead to deeper, more effective learning and better student results? Tightly connected to this is the further question: How can academic researchers help teachers to improve their qualifications for becoming researchers of their own practice?

It is interesting to note that the majority of the studies deal with innovations in the field of teaching natural sciences, especially chemistry. It is not my intention to present all of the different studies and their findings; I will instead concentrate on selected questions, for example: How can one achieve synergy and cooperation among (university) researchers, curriculum developers/school policy makers and teachers? What approaches have proven to be effective in overcoming the traditional dominant role of "experts" and the reluctance of teachers to introduce innovations dictated "from above"? On the other hand, how can one "empower" teachers to become competent in the relatively new and demanding role of researcher and innovator of his/her practice? What strategies have been employed to strengthen the teacher's capacity and willingness to embrace new approaches? There is also the question of the theoretical foundations of various innovations. The studies that make an explicit reference to this are in favour of social constructivism.

A good example of teacher empowerment is presented in the contribution by Eilks, Markič and Witteck (Germany). The study has a solid theoretical foundation and recognises the persistent difficulties in interaction between "different communities" – researchers, curriculum developers and teachers; it presents a solution in the form of the systematic introduction of teachers to participatory-emancipatory action research (as a better model than technical or practical action research). When the teachers' voice is heard, innovations stem from their own convictions and they become advocates of the innovation, in this case cooperative learning. It is important to note that this project has been underway for 10 years.

The case study presented by Keith Taber describes the UK experience of how student teachers can be introduced to performing action research and case studies during their university study. This well-founded study ends on a cautious note, stating that the "eventual success of this innovation cannot be judged for some decades…" (Taber, p. 40).

The case of major reform towards learner-centred chemistry teaching in Thailand is interesting in the sense that it presents thematic examples of interventions to innovate teaching in inquiry mode, such as teaching chemical kinetics. Students had to design experimental procedures themselves, and there was evidence of enhanced learning outcomes. An interesting observation is the uneasiness of some teachers and students who were not accustomed to learner-centred, more active learning and "it will take some time [my emphasis] for all stakeholders to become comfortable with this" (p. 218). There is also an important reminder to school policy makers: "If there is a mismatch between the assessment processes and pedagogies, the assessment regime wins every time" (p. 218).

The common reminder in these three very well-prepared and successful studies is that of time scale; effective innovations need time to unfold their potential and leave lasting changes. This brings to mind numerous current projects, including those co-funded from European funds, that are expected to "bear fruit" in two or three years; thus, schools and teachers are rushed from one project to another, without having enough time for reflection and real implementation in their everyday teaching.

Good projects do not have to be large; a good example of a small-scale experiment is the study of Rodicio and Sanches on instructional explanations, aimed at revising students' misunderstandings. It is well theoretically founded on the constructivist notion of the importance of existing (mis)understandings – and students' awareness of these – for further learning from instructional explanations; it also documents the efficiency of prompted explanations by test results on retention and transfer. Cardellini (Italy) presents the usefulness of an under-utilised way of representing knowledge; namely, concept maps. Another interesting small-scale study is that by Glažar and Devetak (Slovenia) presenting teaching by GALC (Guided Active Learning in Chemistry), which helps students to develop learning strategies and enhance understanding and motivation through well-guided group work.

As can be expected, quite a number of the studies describe innovations that concern introducing different kinds of technology, mainly computer-based, into teaching. These attempts seem to be successful when technology is embedded in a well-designed, theoretically founded project, as a welcome a tool to achieve clear goals. Good examples of such an approach are the study by Syh-Jong and Jang, embedded in an excellent teacher education programme, or the study by Gulinska and Bartoszewicz (Poland) with a blended learning approach to educating student teachers of chemistry. The fact that small-scale technology can also be successful is proven by Borota's study on music education and the study by Cotič, Valenčič Zuljan, Simčič and Mešinovič on the use of the geoboard (both from Slovenia). On the other hand, introducing technology into a traditional educational environment without further interventions cannot bring about substantial innovations (studies by Umek and Sešek from Slovenia, and Svatonova and Mrazkova from the Czech Republic).

In addition to providing precious information about various innovations, from small-scale to system-wide, and the teacher's role in them, this international monograph also offers a lot of material for further reflection. Successful experiments and innovations raise the eternal question of transfer: How, if at all, can best experiences be transferred to other environments? How can we achieve a spread of good innovations? Do we have to start from scratch every time? Then there is the question of what makes an innovative project successful. Success does not usually come from short-term projects, introduced in a top-down fashion, nor from merely introducing spectacular high technology. Teachers are central actors, but they have to be supported in their new, demanding role by competent researchers operating within the framework of long-term, theoretically well-founded projects.

Tomšič Čerkez, B. and Zupančič, D. (2011). Play Space [Prostor igre]. Ljubljana: University of Ljubljana, Faculty of Education and Faculty of Architecture. 164 p., ISBN 978-961-253-053-2.

Reviewed by Borut Juvanec

Children are our future, play is their work. Work strengthens children and develops their capacities, skills and thinking. So it matters how a child plays. Above all, it matters where s/he plays, how s/he grasps the environment, since play connected with a space encourages discoveries. In a restricted, dark, badly organised space that is poorly articulated, a child cannot develop a feeling for clear thinking, for wide recognition, for relations between people, for freedom of thought.

So the space in which a child lives, and in which s/he works, is very important.

Not a lot of books have been written about play, especially not in the field of architecture, the design of space. The present publication is not just a handbook on the theme of play and planning playgrounds; as well as reviewing existing solutions in the world, it analyses them, considers them and proposes further solutions.

The authors have systematically, critically and fully developed the subject of play and its impact on architectural composition in space: at first entirely theoretically, with examples and possibilities given.

Space is always limited by actual, physical and apparent, psychological elements. Limitation is a particularly important element of children's education; it can influence them negatively or help them to develop thought processes in connection with space. A well-designed space must enable play, encouraging and developing it. In this context, two professions are important: pedagogy and architecture. By providing possibilities, architecture develops the child's thinking, so that the child actively intervenes in the architecture; so that in the given possibilities the child invents something new, something that is actually original but has been unobtrusively provided by the architect. Pedagogy supplements its own intervention with elements of architecture, which thus simultaneously become limitation and encouragement.

The combination of the two sciences is much more than merely their sum.

For example, a fence is a restriction intended for safety, but sometimes also ensuring survival. The detail of a fence that is adapted to the hand is an important learning element for a child; the child studies it, understands it and finally grasps it as a functional detail that is useful for him/her. Then s/he no longer notices it – until it is no longer there. Then the child misses it: it is good, and s/he simply no longer remembers the bad. Nature is said to be cruel; so is a child, who links elements in an unbelievably imaginative way. This sense leads a child to simple solutions that are functional, comfortable and, in the end, beautiful. Such, too, is architecture, especially in wood. Wood is a warm, human material, which a child in particular knows how to appreciate if it is elementary, simple and functional. A child can thus be a test for design: if s/he likes a detail it is certainly good. The authors talk about the life cycle, part of which is certainly searching, recognising and understanding space.

Exterior and interior spaces, which the authors distinguish in accordance with external influences, are extremely important in this. In bad weather conditions, a child quickly turns to the inside; in good weather, s/he wants to go out. Good architecture enables this; moreover, through the apparent links between interior and exterior spaces it encourages observation. Otherwise, how is a child to understand the physical properties of water between liquid, steam and ice? Nature is the best teacher; it need only be allowed to show these properties. The authors demonstrate precisely this example, and in this they have an extraordinary advantage: multi-professionalism.

Their relation thus has even greater importance, as they write it as several experts: two architects, a pedagogue, a painter and an economist. The authors of the book are both simultaneously professionally and scientifically proficient and personally committed. What is relevant here is that they are not just speaking on the basis of foreign experiences, but above all on the basis of their own experiences; and they did not have children 'sometime in the last century'; they have them here and now. This is apparent throughout the book and in every detail. They are writing with love, although their scientific approach sometimes restricts this.

The basic findings of the content are:

- Play is a way of growing up in a space in which relations among individuals are established and bonds between individuals in the space are reinforced. Play enables the discovery of a child's own identity and his/her own capacities in relation to himself/herself, to others, to the community, to various social groups and, of course, to the space. The space of play defines an individual and his/her sense of survival. Good play is play that enables reflection and offers an individual his/her own and common active expression.
- The contents of the book raise the question of planning spaces in

which the language of play begins to find full expression (boldness, investigation, laughter, joy, expressing ideas and thoughts, creativity).

- Education is thus present at every moment: all activities are subordinate to education, deliberately unconsciously – for the child, for the teacher and for parents. This is precisely the result of the considered design of space that enables these activities, encouraging and developing them.
- The book discusses the elements that are the foundation for this: shape, colour, order of elements, details and the whole, beginning and end, entrance with or without exit. These are elements that are only apparently merely technical; in the hands of real experts, they become tools for education, functioning unconsciously and effortlessly. Moreover, in the right environment work is fun. If we look at a child who is creating, s/he is serious; above all, this is work for him/her. It is also important that a child evaluates work very strictly and appreciates it. For us, this is play; for the child, it is work. This needs to be understood.
- Nor should it be overlooked that children are not stupid, that they understand things about which adults only whisper in front of them. The environment, the space, is precisely the element that enables this.

The last complete monograph dealing with the sphere of play was written in the 1970s, more than 30 years ago. A great deal has changed since then; new needs and new possibilities have appeared. Together with needs, new possibilities for implementation are opened every day: the availability of materials, their quality, breadth of use, appearance and final finish and, not least, their economics. With ever greater purchasing power – regardless of oscillations and recessions – we must choose only the best for children, as a Scottish proverb says.

So the book Play Space is welcome and necessary for architects in planning, for pedagogues in bringing up groups, and for parents in bringing up individuals, as well as being useful in general for the child.

The book is divided into chapters such as Play, Space, Play Equipment and Play Space. At the end, as any scientific publication, it has the scientific appendices, here presented as References, Abstracts in Slovene, English, Castilian and German, an Index and a Biography of the two authors.

The chapter Play talks about the importance of play for children, about development, and about the senses that are bound to space, discussing perception and experience. These are the theoretical foundations, revealing questions while simultaneously pointing to answers.

The second chapter is entitled Space. Here the authors consider mankind in space, with particular stress on children in space intended for them and in space intended for adults. The authors continue by dealing with art and the design of space that is educational and laboratory, thus theoretical and practical. A playground is an especially important element, as an external space that is differentiated and yet simultaneously connected with the interior.

Play Equipment is a very important section. In this chapter, the authors consider the theory of design that enables, encourages and controls play. In particular, the idea of order and composition is distinguished, which enables a division of work, linkage, superstructure and encourages active and directed thinking. The importance of the design of equipment for play as a subject of the 'design of space' (= architecture) is actually the practical implementation of theoretical foundations. Materiality introduces a new concept of the choice of materials, the relation to the materials and the location, which rounds out the life cycle, both of the child and of the play equipment, for parents and teachers, for the organisers of education and for architects. An important contribution of this thinking is the importance of variety, which is expressed in play and in play equipment and is the fruit of both the architect and the teacher, taking into account the wide scope of the profession and science.

The monograph is sensibly planned, with a clear index including subheadings, while the chapters are separated by coloured pages, clearly indicating the organisation and content of the book. This clarity is reinforced by the presentation all of the scientific findings in graphic form.

The book is divided into chapters that end with 'conclusions', providing a kind of summary of the problem described. Since it is not possible to translate everything, these conclusions are translated into four languages, which thus provide a summary of the whole book in educational terms as the authors develop some details in the book itself. If these conclusions are combined into a unitary text, we obtain the content of the book in brief, as well as its emphases. Although perhaps not planned by the authors, the result is well considered, as the system by which they have developed the question of the design of a play space. As with space, they have arranged the chapters one after another so that they are logically connected and mutually interwoven. Thinking about space thus obtains a completely new meaning, clear and logical, through the composition of the elements of the book itself. Education, therefore, which has developed by itself. The best education, attested in the place itself.

Today, we must do everything within our power to enable a child to develop into a free individual with a clearly expressed personality; this is a condition for the socialisation of each individual and for the shaping of society as a whole. Society is a composition of individuals, and the strength of a society is that which is brought by its weakest link.

It is precisely play that is an element that enables the development of the less talented, less developed and less comprehensive individual, to whom we must provide at least equal opportunities.

Design and graphics are elements that unconsciously bring aspects of education close to a child, enabling him/her to understand things that s/he would not otherwise grasp.

Space is more important than we imagine.

And play has more importance than we ascribe to it.

And a child is the most important of all. If only the best is good enough for a child, this is also true for designing the environment in which s/he lives and develops.

I am particularly pleased that the Faculty of Pedagogy and the Faculty of Architecture are the co-publishers within the framework of the University of Ljubljana. I am an architect myself and, of course, I see space from my own point of view and with my own limited knowledge. Architects are often reproached for being one-sided, often justifiably. On this occasion, this one-sidedness has been surpassed, despite the fact that both of the authors are architects, the theme has been scientifically treated yet reads as a story. The educational element, about which the authors continually speak, is thus applied first to themselves and only then to others. This is fair, and it is successfully implemented.

It should not be overlooked that the authors are not talking about work in the book, they are working. They have worked, in fact. The illustrative material is carefully chosen and supplemented with diagrams, something that is missing in some books on similar themes (in architecture as well as in pedagogy). The sketch is not an end in itself – it does not have artistic ambitions and does not attract attention – it simply supplements the content and explains the functioning or the impact of design in space.

The excellent, hand-drawn line expresses the content of the tale and the character of a man who knows what he wants and knows what needs to be said. A drawing says more than a thousand words.

This does not just apply to both of the authors; the carefully selected pictures by youngsters supplement the thinking of adults and the pictures from work testify to the enthusiasm, desires and aspirations of the young generation, which wants to actively intervene in its environment, an environment that adults tailor for it.

This, though, is already the content of the book, which talks about architecture and about education but says much more.

This excellent book opens up some problems that to date have not been recognised, have not been articulated; it explains, describes and proposes solutions for tomorrow. Perhaps the present book in this field will be followed by a similar work from the psychological point of view, from the linguistic, historical or artistic perspective, recording the characteristics of the individual, special groups, local characteristics or the culture of society, space, time, culture.

That will already be a new book; it cannot surpass Play Space.

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