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Information Technology Implementation: Analysis Theoretical Methods and Frameworks

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Abstract. This article analyses the landscape of research on information and communication technology (ICT) in education. It reviews the theory and practices of ICT research. The first chapter of the article investigates general theoretical research methods. The second chapter analyses the main peculiarities of ICT implementation analysis. The article presents the main concepts and definitions of research theory, it discusses possible evaluation aspects of ICT use in education, classical features of ICT research frameworks and their main components. While analysing the elements of research frameworks, structure and peculiarities of education system are discussed briefly. The article also reviews the main types of research of ICT use in education and analyses evaluation problems of ICT implementation into education.

Key words: information and communication technology (ICT), implementation and research of ICT into education, methods and efficiency of ICT, use of computers in education, education research.

Introduction

Information and communication technologies (ICT) are increasingly used in various fields of education. This field of use of new technologies is being researched for more than twenty years. Scientists from various countries carry out thousands of research every year. Investigation of ICT implementation into education may have different goals. Thus, various research methods can to be applied. In the earlier years, computerization and ICT implementation into education was little analysed in Lithuania. Several years ago, there were only few reliable and scientifically grounded research in this field (e.g., Markauskaitė, 1997b). Now the situation changes substantially. The society and the government of the country pay more attention to ICT implementation into education. Lithuanian scientists have got to be more interested into the problems of this field. The review of new Lithuanian scientific publications (e.g., Informacijos mokslai, 2001) shows that during several last year tens of experiments and research on various ICT implementation aspects have been carried out. Undoubtedly, in the future, the interests of scientists in this field will increase even more.

Analysis of ICT implementation into education is a specific cross-subject research field. That is why very important to know theory and practice of research, and according

to that, to choose proper methods of analysis. The goal of this article is to analyse and summarize global experience of research on ICT implementation in education: to review the main methods of research, their particularities and problems. This analysis is based on the review of theoretical literature of educational and ICT implementation research and other scientific publications.

1. Research Methods of ICT Use

Different methods are used to investigate ICT implementation into education. At the most general level, by methodology, research may be divided into quantitative and qualitative and into experimental and non-experimental. Quantitative and qualitative, experimental and non-experimental types describe different dimensions of the method (Fig. 1): each research is usually described by several aspects (e.g., experimental and qualitative, non-experimental and quantitative).

Quantitative vs. qualitative research. Quantitative research applies quantitative measurements for verifying hypothetical generalizations (Hopeful, 1997). According to C.M. Charles, researches that are based on measurements and digital data are called quantitative (Charles, 1999). In such researches, *factors* (or elements), having the greatest influence or giving the best description of the object that is being researched (i.e., ICT implementation), are separated, then assessment *criteria* are defined. According to these criteria, one can evaluate if the goal is achieved. For example, if the goal is to integrate ICT into teaching and learning of different subjects, then the assessment criteria could be students' ability to use various software packages for performing tasks. Indicators are used for measuring the criteria. *Indicator* is a separate or derived statistical data that shows the present condition (Stroll, Fink, 1998). For example, the indicator of frequency of ICT application could be a percentage of lessons in computer lab.

Scientists of education research often point out that everything that can be measured is trivial. ICT implementation is a complex phenomenon: it is almost impossible to describe this complexity only by indicators. C.M. Hoepfl, quoting L.J. Cronbach, states that statistical researches cannot regard many interaction forces of social phenomenon; they ignore many factors that can be important (Hoepfl, 1997).

Fig. 1. The main types of research.

Qualitative research invokes naturalistic approach and attempts to investigate particularities of phenomenon environment (Hoepfl, 1997). Researches that are based on verbal descriptions are called qualitative (Charles, 1999). In other words, qualitative researches mean different investigations, giving the results that cannot be obtained by statistical methods and by other quantitative measures (Strauss, cit. Hoepfl, 1997, 48). Qualitative research considers a complex and dynamic nature of the world. This research can explore the context better than quantitative and it accounts subjective factors. However, quantitative research method is being criticized for its subjectivity and inaccuracy (Charles, 1999).

Qualitative and quantitative criteria are interdependent and cross-explicated: indicators can show quantitative aspects of phenomenon, but the researcher must understand the context and he must account and analyse its effect. The main purpose of quantitative research is to estimate the causality, to present large-scale generalizations and forecasts. Meanwhile the main aim of qualitative research is to analyse and apprehend the phenomenon, extrapolate this experience in similar situations (Hoepfl, 1997).

Many scientists agree that qualitative and quantitative methods can be effectively combined together (Collis, Knezek, Lai, Myisashita, Pelgrum, Plomp, Sakamoto, 1996; Hoepfl, 1997; Liu, Macmillan, Timmons, 1997). The analysis of B. Collis *et al.* provides the evidence how the quantitative and qualitative research methods can complement each other and can provide additional important information (Collis, Knezek, Lai, Myisashita, Pelgrum, Plomp, Sakamoto, 1996). The quantitative results of their research show that computers at schools are usually used for games and for drill and practice. These learning methods are technology intensive, and it is very important for every student to spend enough time working individually with a separate computer. As a consequence, the main problem of many schools is a lack of ICT. Meanwhile the other qualitative research of "successful practices" shows that students in researched schools (i.e., successful schools) do not play computer games and they do not perform computer-aided tests or exercises. Consequently, teachers of these students do not grumble at lack of computers. In their opinion, even one computer in the classroom, if used as information source or data processing tool, can be effectively integrated into teaching and learning.

The analysis of X. Liu *et al.* proves that qualitative and quantitative methods could and must be used in combination (Liu, Macmillan, Timmons, 1997). These scientists made an experiment of computer influence on students' achievements and their attitudes about computers. The quantitative analysis of students' results did not show any significant influence neither on students' academic knowledge nor on their attitudes. Meanwhile qualitative analysis showed important positive impact of computer use on the learning process.

Summarizing, the proper research method should be selected according to the objectives of the investigation. When variety of use of ICT is researched, quantitative methods fit better and when the changes in the learning process are observed, different combina-

tions of quantitative and qualitative methods might be more appropriate (Collis, Knezek, Lai, Myisashita, Pelgrum, Sakamoto, 1996).

Experimental vs. non-experimental research. Researches that investigate processes that happen in real world without any artificial intervention are called *non-experimental.* The efficiency of ICT use (e.g., effectiveness of educational software and hardware tools) is often investigated using *experimental* methods: randomly choosing experimental and control student groups, and manipulating one independent variable. For example, students of one – experimental – group learn the subject using computer tools and students of other – control – group learn completely the same content, but without using a computer. The research measures other – dependent – variables. The conclusion about the effect of independent variable (i.e., use of computer) is based on comparison of the values of dependent variables of experimental and control groups. Experimental researches are often criticized because of various inaccuracies of this methodology. B. Means *et al.*, summarizing different experimental researches, state that interpretation of such research results is rather problematic. First, when new tool is tested, it always involves not only new mean, but also changes in the content and the method of teaching and learning. When the significant differences are found between control and experimental groups, it is not always possible to attribute these findings only to ICT. All context of learning, methods, teacher's and students features or interaction of these variables could have greater influence than used technical tools. Second, simple change of mean is almost never the goal of ICT implementation (Means, Blando, Olson, Middleton, Morocco, Remz, Zorfass, 1993). The interpretation is especially problematic when the research investigates the ICT impact on educational reform, the change of content and the methods of learning and teaching. In this case not only two tools must be compared according to one standard result, but different aspects of effect of new technology must be researched. This involves even such aspects as the process of implementation, and the way teachers and students use ICT. Therefore, more often non-experimental methods are used for these purposes.

Sometimes, in the researches of efficiency of ICT implementation, other specific methods are applied, too. The most popular such methods are "successful practice", "research of technology rich environment", "financial efficiency" (Culp, Hawkins, Honey, 1999; Thompson, Simonson, Hargrave, 1996). These methods can be attributed to quantitative or qualitative, experimental or non-experimental. They are standard combinations of traditional research methods, but these combinations have specific features that better exhibits particular aspects of ICT implementation.

Overall, all ICT research methods are assessed contradictory: choosing any research methodology, some information is inevitably will be lost.

2. Peculiarities of Evaluation of ICT Implementation into Education

The ICT implementation depends on features of the field it is transferred too. That is why one can state that the particularities of the analysed field (i.e., education system) affect ICT implementation as well as evaluation of this process and its results. This adds some

complexity to ICT research planning and performance. The research framework has to consider the structure of education system, the specific aspects of ICT implementation into education and their evaluation.

Firstly, let us discuss the evaluation of ICT implementation from the general perspective, do not considering what level (country, school or class) of education system is being investigated. ICT implementation is one of many other fields of education reform and development. Thus, both special and conventional methods of education efficiency can be used for the evaluation of ICT implementation. For this reason, the article analyses both classical literature on efficiency of education as well as special literature of evaluation of ICT implementation.

2.1. *The Goals of Evaluation of ICT Implementation*

The main goals of evaluation of ICT implementation may be twofold: 1) to evaluate the efficiency of ICT use or 2) to assess and evaluate the process of ICT implementation (Markauskaitė, 2000b).

The evaluation of efficiency of ICT implementation. In order to evaluate the efficiency of ICT, the final goal of this innovation must be identified, i.e., the efficiency of ICT implementation in the class, at school or at the national level. The efficiency is could be defined as the goal or the result that is being achieved (Stroll, Fink, 1998). The evaluation assesses how separate elements (e.g., students abilities, quality and quantity of hardware and software, qualification of personnel and procedures of teachers development) of implementation satisfy the desirable criteria and what should be done to make ICT implementation more efficient.

Evaluating ICT implementation it is important to investigate organizational factors of implementation as well as to analyse its technical aspects. Scientists offer many different models of evaluation (e.g., Akker van den, Plomp, 1992; Fullan, 1996; Michael, 1998; Molenda, 1996; Scheerens, Bosker, 1997). The main factors leading to the success are identified and analysed in these models. Different scientists are analysing different factors, but M. Fullan observes that the results of researches are consistent: they all show that the efficiency depends on a small number of the similar factors (Fullan, 1996). For example, M. Molenda identifies 10 key factors that influence the quality of ICT use (Fig. 2): 1) economic factors of the country; 2) cultural factors of the country; 3) political factors of the country; 4) accessibility of hardware and software at school; 5) maintenance of technology and software at school; 6) personnel; 7) curricula; 8) teacher's development to apply information technology; 9) teacher's proficiency to apply information technology; 10) features of ICT (Molenda, 1996).

Evaluation of ICT implementation using to factors has several limitations. First, such evaluation is not very effective. Researches show that several factors determine the success of ICT implementation, but it is not clear how do they affect. Furthermore, some factors are difficult to control (e.g., unique features of school) (Fullan, 1996). Second, as D. Hopkins *et al.* state, one of the problems associated with all data, especially with data based on researches of efficiency of classes and schools, is that the collected information

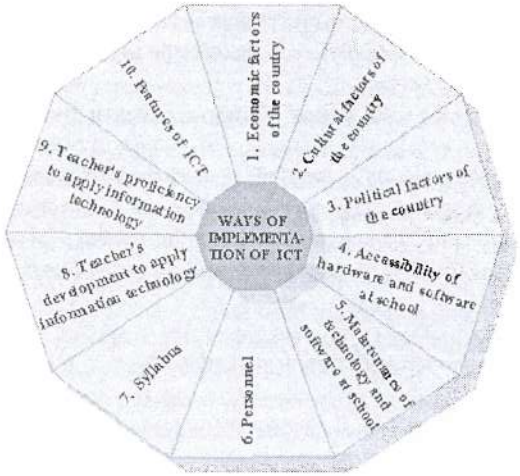

Fig. 2. Factors that influence the efficiency of ICT use (adapted from Molenda, 1996).

is separated from the information, *how* schools are improving (Hopkins, Ainscow, West, 1998).

Evaluation of ICT implementation process. The other way to assess the ICT implementation is not to evaluate the factors, but to investigate separate elements – themes – of implementation process (Fullan, 1996). Researches of this type investigate forces and reasons that induce or hinder the implementation of new technologies. Themes show purposeful efforts and describe organizational factors of ICT implementation and support system. Such evaluation is more organic. It involves more aspects and is better consistent with the holistic nature of implementation of new technologies. Research results show that there are only few important themes in ICT implementation process. Using school evaluation model developed by K. Louis and M.B. Miles, M. Fullan identifies six main themes (Fig. 3): 1) creation of vision; 2) evolving planning and the evolution; 3) initiative and incentive; 4) staff development and support; 5) assessment and evaluation; 6) change (Fullan, 1996). R. McCormick also notices that prime obstructions of implementation lie in school system, i.e., in organization (McCormick, 1992). He supports those scientists, who examine projects and organizational structures for school development and sustainability of these initiatives.

Assessment of efficiency of ICT implementation vs. evaluation of implementation process. Both methods of evaluation are important. Factors structure the whole process into smaller units that are easier to understand and analyse. They stress on the most important aspects of successful ICT implementation. Meanwhile, themes better describe dynamic of the process. Themes and factors work together and they make system of interdependent variables. This combined system defines the success or the failure (Fullan, 1996). In practice, many researches of ICT implementation do not isolate themes from factors. Such complex approach of evaluation is applied into frameworks of many international (e.g.,

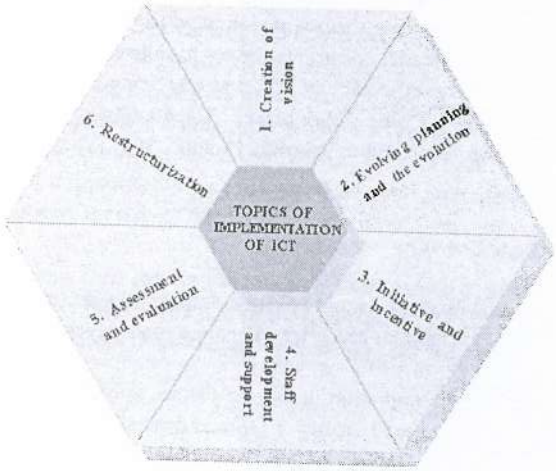

Fig. 3. Major themes of ICT implementation process (adapted from Fullan, 1996).

see Markauskaitė, 2001a; Second Information Technology in Education Study: Module 2, 2000) and national researches (e.g., Law, Yuen, Ki, Lee, Chow, 2000). A good example of that is the research framework of international SITES-M2 study (Fig. 4) that investigates the efficiency ("successful practice") of ICT implementation at the class level.

Research theoretical frameworks differ mostly in the selection of primary and secondary research unit. When factors are chosen as a primary research unit, firstly indicators describing them are evaluated, and then means and organizational structures for their development are assessed (e.g., Akker van den, Keursten, Plomp, 1992). Then the themes are chosen as a primary research unit, firstly organizational processes are evaluated, later

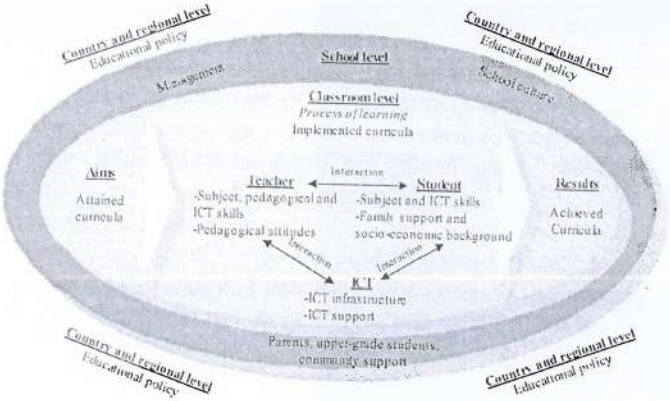

Fig. 4. The example of integrated theoretical research framework for ICT implementation (adapted from (Law, Yuen, Ki, Li, Lee, Chow, 2000)).

effectiveness of factors influencing them is investigated (e.g., Fullan, 1992). For different practical reasons and research constrains factors usually are more emphasized than themes, in many surveys on efficiency of ICT and education change (e.g., Akker van den, Keursten, Plomp, 1992; Collis, 1996; Means, Blando, Olson, Middleton, Morocco, Remz, Zorfass, 1993; Molenda, 1996; Pelgrum, Plomp, 1991; Scheerens, Bosker, 1997; Tarrago, 1993).

2.2. *Factors and their Causality*

Different hierarchical, based on factors research frameworks are applied in many researches on ICT implementation. Now, let us analyse such layered research approach in detail.

Scientists note that four important groups of factors must be regarded while integrating computers into education system: 1) national context; 2) structure of the school; 3) support from outside; 4) features of new technologies (ten Brummelhuis, Plomp, 1993a). On the other hand, ICT has an influence on: 1) education system; 2) process of teaching and learning; 3) students abilities and skills (Tarrago, 1993). According to that, factors that determine process of ICT implementation and it results can be grouped into five interdependent levels – national, school, teacher, class and student. They correspond to the hierarchy of education system. Factors of each level must be analysed separately. In theoretical models of different researches, the levels of education system are abstracted in different ways and the number of layers might slightly vary. For example, W.J. Pelgrum *et al.* separate country, school and student levels (Pelgrum, Plomp, 1991); M. Molenda discerns layers of the country, the school and the class (Molenda, 1996); N. Law *et al.*, analyses the community, the school and the class levels (Law, Yuen, Ki, Li, Lee, Chow, 2000).

Hierarchical theoretical frameworks of ICT implementation that is based on factors have several important features.

First, as B. Means *et al.* emphasize, it is impossible to interfere in student's layer simply presenting new curricula and more advanced technology. Students study in the class with its own organizational structure, culture and agenda. Class, in turn, is at school. Thus, students and teachers must act in this more extensive environment. Moreover, politics of the country and region, resources allocated for education have influence on everything what happens at school (Means, Blando, Olson, Middleton, Morocco, Remz, Zorfass, 1993). Hierarchic research model based on factors accounts this interdependence among different layers of education system (Scheerens, Bosker, 1997).

Second, hierarchic model also mirrors structure of decision-making and implementation. W.J. Pelgrum and T. Plomp state that decisions that promote or hinder the use of computers at school are taken and are implemented at all levels of education system and they are interdependent. In other words, results that must be achieved at the lower levels depend on the goals that are set up at the upper levels (Pelgrum, Plomp, 1991). For example, goals of national education system are proposed at the level of the country, and lower levels – school and teachers – should implement them. The school should organize

education so that learning and teaching would reach the objectives of education system. Teachers working in the class should comply with values of the school. Students' achievements should accord with the process of teaching in the class. Discrepancy between the goals proposed in one level and the results achieved in another one is rather presumable. Separate analysis of factors, that describe different layers of education system, can help to determine such mismatches. These discrepancies can be the reason of inefficiency of ICT implementation. Therefore, their determination can be an important finding of the research.

The aggregation of the results and research frameworks of different researches on ICT integration shows that factors that shape up the efficiency of ICT implementation in different countries, schools or classes are very similar and the number of such factors is not large (see Table 1).

Table 1

The structure of education system and the factors that influence the efficiency of ICT implementation (adapted from (Akker van den, Keursten, Plomp, 1992; Collis, 1996; Molenda, 1996; Pelgrum, Plomp, 1991))

Level of ed. system	*Main actors*	*Exogenous and endogenous factors*	*Result*
National	The Ministry of Education and Science	Exogenous factors	Aims of education system
	Centre for ICT Implementation into Education	*Country characteristics* (economy; social, political and cultural perceptions of population about importance of ICT for education)	
	Pedagogical Institute	*Experience of country to implement innovations*	
	National Examination Centre	Endogenous factors	
	Local authorities	*Country educational policy and its aims* (national primary and secondary legislation; accepted importance of ICT and attained objectives, attitudes of policy-makers and other influential personalities about ICT)	
	Regional Educational Centres and Local Educational Departments		
	Pre-service and in-service teachers training institutions	*Country resources for ICT implementation* (devoted time; resources and means)	
	Various educational expert groups, individual advises	*Leadership, support and help* (decision-making; financing; management; coordination; dissemination; permanent support; development of educational material and its dissemination)	
	National Curricula, Educational Standards, national exams and monitoring system developers	*Evaluation*	
	Authors of textbooks and educational software	*National Curricula* (content; time; tools; teaching and learning methods; coherence of National Curricula with the aims of ICT implementation)	
	Other governmental and non-governmental institutions for development and implementation of education policy, influential personalities		

To be continued.

Continuation of Table 1

Level of ed. system	Main actors	Exogenous and endogenous factors	Result
school	School board and other school self-governing bodes School staff community School administrators School principal	Exogenous factors *Characteristics of the school* (institutions; social and demographic characteristics of students and teachers) *Experience of school to implement innovations* Endogenous factors *Aims of school* *School resources for implementation of ICT* (time; funding; tools) *Leadership, support and help* (process of decision-making; role of principal; encouragement and support from principal and ICT coordinator) *Management of ICT resources* (accessibility of hardware and software; equal opportunities to use ICT) *Technical support* (maintainance of software and hardware; ICT support staff) *Staff development* (training courses; dissemination and exchange of information; collaboration and inter-support) *Evaluation* *School curricula* (content; time; tools; teaching and learning methods)	Organization of teaching and learning process
Teacher	Teacher	Exogenous factors *Characteristics of a teacher* *Teacher's experience, skills to use ICT* Endogenous factors *Teacher's resources for ICT implementation* *Teacher's aims* *Teacher's perceptions* *Teachers skills to implement ICT*	Organization of teaching and learning process

To be continued.

All factors can be divided into exogenous and endogenous (Janssen Reinen, 1996). *Exogenous* are called factors that cannot be changed in a practically feasible way. The experience of the country to implement innovations, teacher's characteristics (age, sex, etc.), student's characteristics (sex, family, socio-economic background and etc.) are the examples of exogenous factors. *Endogenous* are those factors that can be feasibly influenced and changed. For example, national educational curricula and ICT qualification of teachers are endogenous factors, because the National Board of Education and Science can change the curricula, and teachers' ICT skills depend on the given emphasis to teachers development. Classification of factors into exogenous and endogenous is relative in regard to the level of education system. All exogenous and endogenous factors of the upper level are exogenous to all lower levels. For example, the curricula of the country is an endogenous factor of the country layer, because the Board of Education and Science or other country level institutions can change it, but in regard to student, school and teachers levels the national curricula is an exogenous factor, because they cannot change it.

Continuation of Table 1

Level of ed. system	Main actors	Exogenous and endogenous factors	Result
Class	Teacher and students	Exogenous factors **Teaching and learning** *Characteristics and experience of a teacher* *Students characteristics* Endogenous factors *Class resources for ICT implementation; features of available tools* *Implemented curricula* (content; time; tools; teaching and learning methods, organization of teaching and learning process)	Teaching and learning
Student	Student	Exogenous factors *Characteristics of a student* *Home support and background* Endogenous factors *Student's perceptions* *Aims of a student*	Student's skills

The main imperfection of hierarchical research framework is that it simplifies the complex structure of the education and eliminates two-way interdependence between different layers and between factors, i.e., the hierarchy disregards the influence of the lower levels of education system to the upper ones. If this feature is considered, theoretic research model would better accord to the structure and dynamic of education system development, but then it would be too complicated to analyse. Majority of research frameworks of ICT implementation is based on the assumption that computerization of education proceeds from top to bottom. This means that goals and processes in upper levels have the influence on the lower ones, and there is no influence in opposite direction, i.e., lower levels do not affect upper ones. Researches of Lithuanian educational system (Želvys, 1999) prove that such assumption can be applied in analyses of ICT implementation in this country, because this decision-making and implementation model corresponds to the course of Lithuanian education reform.

Table 2

The main ICT features that determine its suitability for education

Characteristics of innovation	*Description*
Comparative advantage	Implemented innovation should suit current educational needs
Compatibility with values, earlier experience and current demands	ICT and other radical educational reforms should not be implemented at the same time
	Innovation should be implemented at the right time (not too early and not too late), i.e., only then, when it corresponds to teaching and learning needs
Degree of complexity	Everyone should understand goals, importance and benefits of innovation
	New tools should be qualitative and practical
Observable results	Benefits of innovation should be obvious and implementers should not to wait for the results too long

Scientists that investigate the implementation of innovations note that various features of innovation, such as its fit to the environment (i.e., education needs) into which the innovation is transferred, determine the successful take up too. Four main features of ICT characterize its suitability for education: 1) comparative advantage; 2) compatibility with values, earlier experience and current demands; 3) the degree of complexity; 4) observable results (see Table 2). These ICT features are the objects of many ICT researches in education.

Summarizing, the analysis shows that ICT integration is a complex process that in parallel goes at all levels of education system. Different features of innovation and outside forces influences this process too. The success of the integration of new technologies can depend both on individual factors of all these elements and on their interactions.

2.3. *The Main Types of Researches of ICT Implementation into Educational System*

Researches of ICT implementation into educational system can be classified on the basis of two main features: evaluation *object* and evaluation *nature*.

Evaluation *object* usually corresponds to the level of educational system: country, school, teacher, class or student.

Country level describes goals of education that must be reached as a result of innovation implementation. Documents regulating this field of education, measures undertaken on the national scale, countrywide organizational and support structure of educational system describe the result the best. For example, in order to implement the ICT at the national level, documents regulating education must accord to the goals of ICT implementation, special projects for educational system computerization must be carried out, teachers ICT development system and activities must be implemented, structure of the national educational computer network must be elaborated. So, researches on ICT implementation at the country level usually analyse the national strategy and governmental programs on ICT implementation. Different international research centres and international

organizations usually concentrate their assessment efforts at this level of ICT implementation. They make country profile comparisons and publish aggregate reports (e.g., Latin America and the Caribbean: Education and Technology at the Crossroads, 1998; Information and Communication Technology in the Education system in Europe, 2000).

Evaluating implementation and efficiency of ICT use at *school*, quantitative and qualitative aspects of the school information system are usually researched: school ICT facilities, school curricula related to ICT, staff ICT development and support system, etc. Assessments of school level are very popular in many countries (e.g., Anderson, Ronnkvist, 1999; Markauskaitė, 2000a, 2000b). It is not too difficult and not too expensive to make large-scale assessments of this level (usually it is enough to gather information from school principals and school ICT coordinators), and they display the general situation of ICT implementation into teaching and learning quite well.

In the early national programs and initiatives of ICT implementation, a school was not considered as an important player in implementation process. Therefore, only basic quantitative data on ICT availability and use were traditionally analysed, and assessment of other school factors was not regarded particularly. Recently, the role of the school as an institution is emphasized into the most programs of education change and development (Fullan, 1992; McCormick, 1992; Michael, 1998). As a result, researches shifted their focus from pure statistical indicators to school performance factors. Now both quantitative factors of ICT implementation and investigation of integration process are regarded as equally important.

The results of many researches show that *teacher's* features and his role influence the efficiency of ICT use (Research Report in Effectiveness of Technology in Schools: Executive Summary, 2000). Evaluations of ICT implementation at teacher's level usually assess qualification, experience of the teacher, his ability to use ICT, applied instructional methods, variety and frequency of applied computer software, as well as other indicators that describe the teacher and are associated with computer integration into their teaching practices. In the recent ICT studies, the focus shifted to teachers' activities and purposeful, planned efforts to integrate the ICT into their teaching practice. Thus, researchers analyse their syllabus and other factors that describe the ways teachers wish and seek to utilize ICT (e.g., Dusick, 1998; Moursund, Bielefeldt, 1999).

Student's level researches show the real results of ICT implementation. Student level studies analyse indicators, factors and changes that are immediately concerned with students learning, attitudes, knowledge and skills (students characteristics, learning, various aspects of ICT use and etc.) and the obtained results (students knowledge and skills) (e.g., Knezek, Myisashita, Sakamoto, 1996; Liu, Macmillan, Timmons, 1997; Markauskaitė, 2001b).

In the research methodologies of various scientific surveys, someone could notice the obvious relationship between sample size and analysed level of education system: the lower level of educational system is being analysed, the smaller sample is researched. This relationship is apparent, as it is expensive and complicated to make large scale (e.g., of the country) assessments at the student level. Thus, there are only few reliable student level researches and analyses (e.g., Markauskaitė, 1997b; Pelgrum, Plomp, 1993; Wenglinsky, 1998).

Computers integration into *class* level is researched by investigating students and teacher's levels in parallel and by analysing interrelations of the obtained results. The results are evaluated with regard to factors of both layers and their links. ICT implementation into class and its efficiency is researched in many scientific works. These researches are important, because they can describe the relation between features of teaching and learning and the obtained result. Class level is broadly analysed by applying experimental and qualitative research methods (e.g., Changing the Conversation About Teaching, Learning and Technology, 1995; Janssen Reinen, 1996; Markauskaitė, 2001a; Second Information Technology in Education Study: Module 2, 2000).

The other important characteristic of research is its *nature*. According to this criteria, two types of researches can be discerned: descriptive and evaluative.

Descriptive researches mostly analyses the present situation and various aspects of ICT implementation into education. They provide quantitative description of the situation: quantity and quality of technology and software, how many students and teachers and how often can access it, in what subjects they use, what are most popular teaching methods of using computers, and etc. In these researches, ICT implementation is analysed *ad hoc*. In other words, the goals of computers implementation are not regarded in these assessments. The causality of the obtained statistical data is not analysed and the efficiency of ICT for attaining the goals is not evaluated either (e.g., Anderson, Ronnkvist, 1999; Markauskaitė, 1997a, 1998).

Evaluative researches emphasize goals of ICT integration and its efficiency. The purpose is to estimate if the use of computers really helps to achieve perceived educational targets. Evaluative researches are usually conducted at the level of student and class. For example, depending on the goals of ICT use in the classroom, such studies may evaluate the influence of ICT on students knowledge of different subjects (e.g., Collis, Knezek, Lai, Myisashita, Pelgrum, Plomp, Sakamoto, 1996), their cognitive abilities (e.g., Collis, Knezek, Lai, Miysashita, Pelgrum, Plomp, Sakamoto, 1996), students computer literacy (e.g., Pelgrum, Plomp, 1993), their opinion or motivation (e.g., Knezek, Myisashita, Sakamoto, 1996).

2.4. *Problems of ICT Implementation*

The main problems of ICT evaluation stem from several sources: ambiguity of the conception 'efficient use of information technology in education' (Glennan, Melmed, 1996); and variety and limitations evaluation methods to access ICT influence (Collis, Knezek, Lai, Myisashita, Pelgrum, Plomp, Sakamoto, 1996).

It is not agreed universally what does 'efficient ICT implementation into education' and 'effective use of computers for education' mean. The term of 'efficiency' is ambiguous for several reasons. First, the targets of ICT implementation depend on the general goals of education and ICT use (Glennan, Melmed, 1996). Second, as new ICT tools become available, the purpose of computers, ways of their use in education and concept of 'effective ICT use' change, too (Becker, 1993; Morsund, 1998). Third, the criteria of efficiency are often contradictory. For example, if the ICT is easily accessible for all students and teachers in different locations, it is not easy to guarantee safety of information

(Stroll, Fink, 1998). Last, scientists use the concept of 'heterogeneous efficiency'. Thus, they point out the different efficiency of the same innovation for different student groups (Stroll, Fink, 1998). For example, computers can be used effectively for educating gifted students, but they can be inefficient for developing those who are lacking motivation.

The evaluation of efficiency of ICT is a complex process not only because ambiguous definition of 'efficiency' conception, but because of other reasons as well. First of the difficulties is dynamic ICT nature. While long-lasting researches are being made, both technologies and research results get obsolete (Glennan, Melmed, 1996; Kosakowski, 1998). The second reason is complexity of educational process. Learning depends on many factors (teachers, students, operating personnel, hardware and software and etc.). Therefore, it is hard to estimate which factors actually affect the result most strongly (ICT implementation, other factors or ICT and all factors as a whole) (Glennan, Melmed, 1996; Kosakowski, 1998; Liu, Macmillan, Timmons, 1997; Wenglinsky, 1998). The last reason is the limitations of research methods. As it was mentioned before, using any method, part of information is always will be lost. Therefore, it is impossible to measure every aspect of ICT implementation and get precise result (Glennan, Melmed, 1996; Tarrago, 1993).

3. Conclusions

In the world, ICT implementation into education is widely investigated. Researches have different goals and apply different research methods.

Methods used for investigating ICT implementation can be quantitative and qualitative, experimental and non-experimental. Different combinations of these methods could explain different aspects of ICT implementation. Selection of particular combination of research methods depends on the goals of analysis.

Goals of evaluation of ICT implementation could be twofold: to estimate the efficiency of implementation or to investigate the process of implementation. Goals determine the way the evaluation has to be conducted. If the result is evaluated, the main factors that show the quality of result are analysed. If the process of implementation is assessed, themes that show dynamic of the process are investigated. In many researches, both the themes and the factors are combined and investigated together.

Decision on the main themes and factors that are investigated in particular research depends on the objectives of research and on the structure of educational system.

Its important to recognize that selection of particular research methods and development of research framework is a subjective decision. All methods have their pros and coins, and applying any research technique some information inevitably will be lost. Development of appropriate research framework requires all good theoretical knowledge of research techniques, experience in the field of education and ICT implementation, as well as scientific intuition.

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Informacijos technologijos diegimo švietime tyrimai: teorinių metodų ir modelių analizė

Lina MARKAUSKAITĖ

Šiame straipsnyje nagrinėjama informacijos ir komunikacijos technologijos (IKT) diegimo švietime tyrimų teorija ir praktika. Pagrindinis dėmesys skiriamas tyrimų metodų ir jų ypatumų analizei. Straipsnyje pateikiamos pagrindinės tyrimų teorijos sąvokos ir jų apibrėžimai, aptariami galimi IKT diegimo švietime vertinimo tikslai, klasikiniai tyrimų teorinių modelių sudarymo principai bei pagrindinės modelių komponentės. Nagrinėjant pagrindinius teorinio modelio faktorius, trumpai aptariama švietimo sistemos struktūra bei jos specifika. Straipsnyje taip pat apžvelgiami pagrindiniai informacijos technologijos diegimo švietime tyrimų tipai ir analizuojamos IKT diegimo vertinimo problemos.