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Which factors obstruct or stimulate teacher educators to use ICT innovatively?

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Abstract

This article discusses the factors which stimulate or limit the innovative use of ICT by teacher educators in the Netherlands. Innovative use of ICT is defined as the use of ICT applications that support the educational objectives based on the needs of the current knowledge society. Explorative path analysis and case studies were used to study the potential influencing factors. Results show that several factors on teacher level influence the implementation of innovative ICT-use in education. Especially, teachers who are so-called 'personal entrepreneurs' are important for the integration of ICT in teacher education. School level factors turn out to be of limited importance for innovative use of ICT. This indicates a limited involvement of the management of teacher training institutes towards the use of ICT within the curriculum.

Keywords: Improving classroom learning; Technology use in the classroom; Factors affecting technology use; Teacher education

1. Introduction

Since the mid-1990s, the Dutch government has provided teacher education institutes with special facilities to play a pioneering role in the integration of information and communication technology (ICT) in education. The governments' policy has focussed especially on teacher education institutes because they are responsible for the education of the teachers of tomorrow. These teachers must be able to prepare young people for the knowledge society in which the competency to use ICT to acquire and process information is very important (Ministry of Education, Culture and Science (MECS), 1999; Plomp et al., 1996).

Generally, three objectives are distinguished for the use of ICT in education (Plomp, ten Brummelhuis, & Rapmund, 1996): the use of ICT as object of study, the use of ICT as aspect of a discipline or profession; and the use of ICT as medium for teaching and learning. The use of ICT in education as object refers to learning about information and communication technology, which enables students to use ICT in their daily life. The use of ICT as aspect refers to the development of ICT skills for professional or vocational purposes.

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The teacher education institutes have to educate their students in the use of ICT applications used in primary education. The use of ICT as medium focuses on the use of ICT for the enhancement of the learning process of students. By means of ICT students can achieve their learning goals more effectively. Within teacher education there is overlap between the use of ICT as aspect and as medium. A teacher educator, who uses ICT for the enhancement of the learning process of his students, also shows students at the same time how ICT can be used in primary education.

Considering the role the teacher education institutes are expected to fulfil, it is important that a teacher educator provides his students (future primary and secondary teachers) with 'good' examples. ICT is not just regarded as a tool, which can be added to or used as a replacement of existing teaching methods. ICT is seen as an important instrument to support new ways of teaching and learning. ICT should be used to develop student's skills for cooperation, communication, problem solving and life long learning (Plomp et al., 1996; Voogt, 2003; Voogt & Odenthal, 1997).

Although computers have become widely available in Dutch teacher education institutes, the use of ICT for learning purposes by teacher educators is still very limited (Ten Brummelhuis, 2001; MECS, 2002; Van den Dool, 2003). A national survey on the implementation of ICT (*The ICT-monitor*) shows that two-third of the teachers of these institutions are very positive about the value of ICT for education (Ten Brummelhuis, 2001). However, only half of the teacher educators uses ICT regularly in their courses. These teachers use ICT mainly to prepare lessons and to conduct administrational tasks. The use of their students is limited to word processing and searching information. Very few teachers introduce students to the educational software available for primary and secondary education. Students themselves are complaining about their lack of knowledge concerning the possibilities to use ICT as a tool to support new ways of learning. Both the use of ICT as medium and the use of ICT as aspect, is still limited within teacher education institutes. Most of the teacher education institutions seem to be in phase of the so-called "first order change" (Fullan, 2001); training institutions have focused mainly on the infrastructure which is needed for the change (implementation of ICT) but the learning arrangements and teaching styles still remain unchanged.

There are promising examples of ICT-use in support of new learning arrangements (Haymore Sandholtz, Ringstaff, & Dwyer, 1997). So why is the use of ICT by these teachers still very limited, despite governmental encouragement, the available infrastructure and positive attitudes of teachers? Using the data of the ICT-monitor, this study explores factors and conditions that are important for the educational use of ICT by Dutch teacher educators. This research focuses especially on the "innovative ICT-use" by teachers. Innovative ICT-use means that ICT is used as a tool to support the educational objectives, which are important for the preparation of children for the knowledge society, including skills for searching and assessing information, cooperation, communication and problem solving. In this article the following research question will be addressed: *what factors promote or obstruct the innovative use of ICT by teacher educators in their education*?

2. Conceptual framework

During the last two decades, the implementation of ICT in education has become an important topic in research on educational reform. One of the first large-scale international comparative survey on computer use was the IEA-study *Computers in education* (Comped) which was conducted from 1987 until 1990 (Pelgrum, Janssen Reinen, & Plomp, 1993). This project focussed mainly on different aspects of computer use by teachers and students and the infrastructure in primary and secondary schools. The successor of Comped, *The Second Information Technology in Education Study* (SITES, 1997–2007) will be aimed at the exploration of factors and conditions that are influencing the implementation of new learning arrangements supported by ICT (Pelgrum & Plomp, 2005). However, SITES is one of the few studies in which factors influencing innovative ICT-use and innovative learning arrangements will be assessed. Most of the research on the implementation of ICT in schools is focussing on factors that influence the use of ICT in general. It is often assumed that the use of ICT will lead to changes in learning arrangements and teaching methods but factors influencing innovative ICT-use are not explicitly analysed (e.g., Becker, 2000; Pelgrum, 2001).

The research literature on the implementation of ICT in general shows that it involves a large number of influencing factors (e.g., Ten Brummelhuis, 1995; Mumtaz, 2000). Several review studies have produced an extensive overview of influencing factors and conditions for the implementation of ICT (BECTA, 2004; Ely, 1999; Grunberg & Summers, 1992; Mumtaz, 2000). In these overviews, a distinction can be made between non-manipulative and manipulative school and teacher factors. Non-manipulative factors are factors that cannot be influenced directly by the school, like age, teaching experience, (educational) computer experience of the teacher or governmental policy and the availability of external support for schools. Examples of manipulative factors are attitudes of teachers towards teaching and ICT, ICT knowledge and skills of teachers, commitment of the school towards the implementation process and availability of ICT support.

Research on the implementation of ICT in schools has also shown that these school and teacher factors are interrelated (e.g., Ten Brummelhuis, 1995; Janssen Reinen, 1996). The success of the implementation of ICT is not dependent of the availability or absence of one individual factor, but is determined in a dynamic process involving a set of interrelated factors (Ten Brummelhuis, 1995). For a Dutch quantitative study on the introduction of computers in Dutch in secondary schools, Ten Brummelhuis (1995) developed a framework in which a distinction is made between manipulative and non-manipulative factors. Using structural equation modelling, he not only identified factors explaining the degree of computer use but also their interrelatedness. For example, he found that the implementation of computers in school were not solely determined by support activities on either national level or school level, but is most effective when external support reinforces school activities.

In this present study, review studies on the use of ICT by teachers were used for the identification of relevant factors to be included and categorised in a conceptual framework (see Fig. 1). The framework is largely build on the framework of Ten Brummelhuis.

In this framework, a distinction is made between *exogenous* (non-manipulative) factors and *endogenous* (manipulative) factors on either the school or the teacher level. The *implementation outcome* is the dependent variable in this framework and refers to the innovative use of ICT by teacher educators. An overview of the factors mentioned in the review studies, is presented in Table 1 (see next section). In this table, these factors are categorised in exogenous and endogenous factors on school or teacher level.

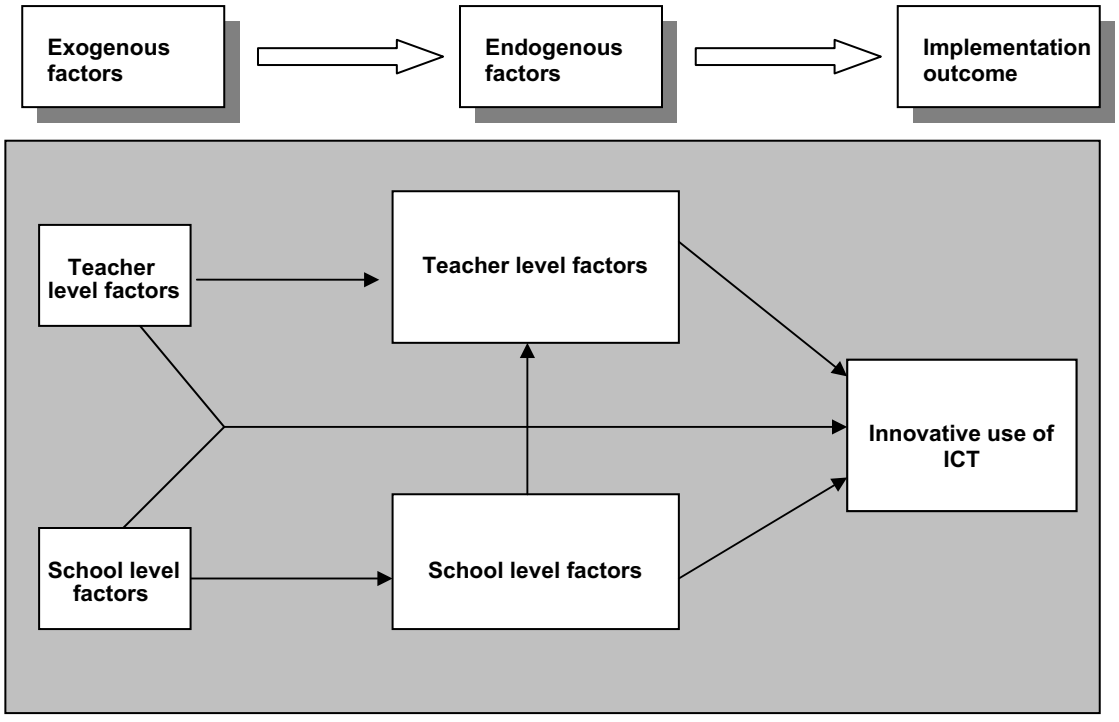

Fig. 1. Conceptual framework based on Ten Brummelhuis (1995).

Table 1
Overview of factors which *positively* influence the implementation of ICT in education based on BECTA (2004), Ely (1999), Grunberg and Summers (1992) and Mumtaz (2000)

Factor	Operationalization in ICT-monitor teacher questionnaire[a]	Cronbach alpha
Exogenous teacher level factors		
Age (younger teachers)	Yes	n.a.
Gender (male)	Yes	n.a.
Educational experience	Yes	n.a.
Experience with the computer for educational purposes	Yes	
Exogenous school level factors		
Parent and community support	No	
Role of the government	No	
Endogenous teacher level factors		
Self-image	No	
Student-oriented educational philosophy of the teacher	No	
Positive views to ICT in general	No	
Positive views towards the contribution of ICT to education	Yes (13 items). A high score indicates a positive attitude.	.88
Positive views about the impact ICT has on their work/perceived changes	Yes (5 items) A high score indicates a positive perceived impact.	.63
Student-oriented pedagogical approach	Yes (8 items). A low score indicates a teacher centred approach, a high score a student-oriented approach	.67
Personal entrepreneurship/professional engagement	Yes *Communication/Interaction*: the amount of contacts of teacher educator with colleagues and other experts within and outside the institution in relation to ICT (4 items) *Use external network*: the number of external organisations/persons from which the teacher educator experience ICT-support (10 items)	 0.78 0.82
Self confidence	No	
(Didactic) ICT competence	Yes (10 items on didactic ICT competence)	.87
Willingness to change	No	
Endogenous school level factors		
History of innovation attempts	No	
Availability of vision about the contribution of ICT to education	No	
Goals of the school ICT policy	No	
Available support to computers-using teachers in the workplace	No	
Level of and accessibility to the ICT-infrastructure	Yes, number of available computers[b]	n.a.
Availability of time, to experiment, reflect and interact	No	
Availability of financial support	No	
Support structure	Yes (3 items): amount of experienced support from management and ICT support personnel	.64
Actions and commitment of school management	No	
Existence of rewards or incentives	No	
Collegial interaction and reflection (working climate)	Yes (9 items) A high score indicates a perceived supportive climate	.82
Level of and quality of training of teachers	Yes (1 item)	n.a.
Training of school management	No	
Internal information and communication systems of the school	No	

[a] The instruments of the ICT-monitor are available at: www.ict-monitor.nl.
[b] Due to a large amount of non-response on the question this factor could not be included in the analyses.

3. Design of the study

3.1. Data collection

The data used in this study were collected though the ICT-monitor. The ICT-monitor (1997–2000) was a large-scale national study in the Netherlands on the implementation of ICT in primary, secondary and teacher education as well as in vocational education (Ten Brummelhuis, 2001). Data were collected by school, teacher and student questionnaires. Although the project was set up as a longitudinal study, the questionnaires for the teacher education institutes changed too much to make relevant comparisons over the years. For this study, the data of the ICT-monitor of 2000 were used, because it offered the most information about the factors identified in the literature review. The factors for which indicators were available in the ICT-monitor teacher instrument have been selected for further explorative analyses. Table 1 indicates which of the factors identified in the literature review, were operationalized in the ICT-monitor.

The secondary analyses were conducted on the data of teacher educators for primary education, who taught students in the fourth year or third year. Because of the low number of teacher education institutes (31) for primary school teachers in the Netherlands, all teacher educators (in total 431 teachers) received a questionnaire about their ICT-use and topics like their attitudes toward ICT and perceived limitations in ICT-use. Less than half (48%, $n = 210$) of the teachers participated. Through a 'screening survey' each teacher education institute was asked for each teacher educator in the institute, whether they used the computer in their classes. The results showed that the non-responding teachers did not differ from the participating teachers in their ICT-use (see for more information Drent, 2005).

3.2. Variables

For the potentially influencing variables, factor and reliability analyses have been carried out on sets of items referring to one factor. Sets of items with a reliability coefficient Crohnbach Alpha of at least .60 were included in the analysis. A description of the potentially influencing factors for which operationalizations were found in the ICT-monitor data, including their reliability, are presented in Table 1. A more extensive description of these variables can be found in Drent (2005).

Because of the importance of the innovative use of ICT in this study, the operationalization of this scale is discussed in more detail. As described before, in this study innovative use of ICT is defined as the use of ICT in support of learning in the knowledge society. Innovative ICT-use is not aimed at specific technologies, but at the way, those technologies are used in education. The use of ICT should support new more student-oriented arrangements of education

According to Drent (2005) and Voogt and Odenthal (1997) the use of ICT can be regarded as "innovative" if it has the following two characteristics:

1. the ICT application facilitates student centered learning: students can, to a large extent, influence their own learning by adapting the learning process to their own needs and interests,
2. there is a variation in ICT-use: different ICT applications are combined, when only one application is used, it is less likely that the teacher educator had integrated the use of ICT in support of a student-oriented arrangement of education.

Based on research and discussions with experts in the area of ICT in education, two restrictions are made to the kind of applications which are included in the innovative use of ICT scale. Applications which are primarily aimed at the substitution of existing teaching practices, like drill and practice programs were excluded. They were not considered to be programs which can be seen as tools that facilitate student centered learning. Furthermore, applications like word process programs were excluded. Word processing programs haven according to Jonassen (2000) only limited value for the support of the learning process. These programs are primarily aimed at making the learning process more efficient. Perkins (1993) calls this the 'finger tip' effect. The activity is executed the same as before only more easily and quicker.

Table 2
Overview of applications underlying the dependent variable "innovative use of ICT"

Applications	
Introducing	I let students work with the computer to orientate themselves to a new subject
Information gathering	I let students gather information from electronic databases
Data processing	I let students use the computer to process collected data
Problem solving	I let students work with a computer program in which a problem is given that they have to solve, supported by the computer
Presenting	I give students an assignment to give a presentation supported by a computer

Through reliability and factor analyses and consultation with experts on the use of ICT in education, five ICT applications which are expected to support student centered learning were identified in the teacher questionnaire (see Table 2). The dependent variable "innovative ICT-use" consists of the sum score of these items (Cronbach alpha = .61).

3.3. Secondary analyses

The first phase of this study consisted of secondary analyses on the data of the ICT-monitor. The Partial Least Squares (PLS) analysis technique (Sellin, 1990) was used to explore how influencing factors are interrelated and what kind of influence these factors have (directly or indirectly) on the dependent variable, the innovative use of ICT. This technique is especially developed for research that requires exploratory analyses. The strength of the PLS technique is that better predications can be made about the interrelationships between factors in the real world, when no theoretical model is available (Pulos & Rogness, 1995). When research is aimed at confirmatory tests of a theoretically well established path model, other methods like Amos or LISREL are more appropriate (Bos & Kuiper, 1999). The path model in this study has been developed after decisions concerning the instruments and variables were made. Therefore, the nature of the analyses is considered as more exploratory than confirmatory.

First, an initial model was estimated. This model included all factors that were identified in the literature review and were operationalized in the ICT-monitor (see Table 1). The interrelations between factors in the initial model were based on both the literature review, found correlations in the ICT-monitor data and the expected relations presented in the conceptual framework (Fig. 1). With PLS both an outer model (the estimation of latent variables as linear composites of their associated manifest variables) and an inner model (estimation of direction and strength—path coefficients—of links between latent variables) were evaluated and if necessary, trimmed. Through cycles of analyses the final, trimmed model of interdependent factors was developed. A direct relationship between two factors was considered meaningful when the beta coefficient was larger than .15. Other criteria that were used for trimming the model are weight, loading, communality, redundancy, tolerance (See for more details: Afrassa, 1999; Campbell, 1996; Falk, 1987; Sellin, 1989, 1990; Sellin & Keeves, 1994, 1997)

PLS-analysis does not provide a goodness-of-fit-measure. There is no cut-off point available for making a distinction between adequate and non-adequate fit of the path model. However, to consider the value of the estimations of the links between the latent variables, a jackknife procedure can be used. The jackknife procedure in the PLSPATH program omits one case at the time (blindfold) and re-estimates the model parameters on the remaining cases. Rather than utilizing one sample to estimate the model parameters and another sample to assess the validity of the estimates, the data set at hand is repeatedly split into an 'estimation set' comprising $n - 1$ cases to the nth case (Janssen Reinen, 1996, p. 86). The jackknife procedure within the PLS path program produces a jackknife mean, a jackknife standard deviation and a Q^2-value. The jackknife mean is comparable to the beta coefficient. The relationship between two latent variables is considered significant when the jackknife mean has twice the size of the jackknife standard deviation. The Q^2-value is comparable to the explained variance indicated by R^2 in normal regression procedures. The difference between Q^2 and R^2 is an indication for the amount of 'noise' or instability in the path model (Sellin, 1990). A small difference between Q^2 and R^2 indicates a stable model. The use of the jackknife procedure within the PLSPATH program is espe-

cially suited when the sample size is relatively small, as is the case in this study. When discussing the results of the PLS-analysis both the variance explained in terms of R^2 as the results of the jackknife procedures, in terms of Q^2 will be reported.

A more extensive description of the evaluation criteria and the evaluation of the initial and the in-between outer and inner models can be found in Drent (2005). In this article only the final model is presented (see next section).

3.4. Case studies

In the second phase of this study, the results of the PLS analyses were used as input for case studies. The selection of the four teacher educators was based solely on their high score on the scale for the intensity of innovative use of ICT. Two teachers were male and two female, the teachers varied in the subjects they taught: mathematics, science and technology, religion and handicrafts.

The main goals of the case studies were:

1. to validate whether the PLS model of interrelated factors is being found in the educational practice of four teacher educators,
2. to deepen the insight in the main results of the PLS analyses.

The case studies consisted of interviews with the teacher educator and a few of their students. Data were gathered through semi-structured interviews. To analyze the results, the information from the four teachers was extracted and reorganized into a cross-case comparative format. To compare the importance of factors every variable for every teacher educator was scored on a five-point scale. Apart from the researcher, two assessors have evaluated the interview reports and judged whether factors found in the PLS-analyses are present and play a role of importance for the implementation of ICT by the interviewed teacher educator.

The results of the case studies will only be discussed in relation to the found results of the PLS-analysis, therefore the design of the case studies is not described extensively in this article. More information on the design and instruments of the case studies can be found in Drent (2005). In the next section both the results of the PLS analyses and the results of the case studies will be presented.

4. Results

In the final PLS-model, 43% variance is explained (see Table 3). This final model was the most optimal model based on the used evaluation criteria. Furthermore, the amount of 'noise', the difference between Q^2 and R^2 is very small. This indicates a stable model. Table 3 also shows the direct effects (Beta coefficients) found in the final PLS-model. The results of the PLS analyses show that four factors have a direct positive influence on the dependent variable innovative use of ICT by the teacher educator: a student-oriented pedagogical approach (.18), a positive ICT attitude (.18), computer experience (.23) and 'personal entrepreneurship' (.33) of the teacher educator.

However, the influence of teachers' pedagogical approach is more limited than is often suggested in the research literature (e.g., Becker, 2000). In addition, in contrast to expectations, teachers' competence in ICT-use (perceived by the teacher) has no direct influence on his or her innovative ICT-use.

4.1. Pedagogical approach

The direct relationship found between a student-oriented pedagogical approach and the innovative use of ICT conforms to results found in other research (e.g., Niederhauser & Stoddart, 2001). However, the impact of the pedagogical approach on innovative use of ICT is limited (Beta coefficient: .18). Based on the assumption that education in the knowledge society will be more student-oriented in the learning process, it was expected that the relationship between the pedagogical approach of the teacher educator and the innovative use of ICT would be stronger. The results of the PLS analyses show that the direct influence of the years of

Table 3
Direct and total effects, explained variance (R^2) and Q^2 found through the PLS analyses

Latent variables	Direct effects	Total	R^2	Q^2
Computer experience			**0.04**	**0.02**
Gender	0.20	0.20		
Internal support structure			**0.15**	**0.13**
Working climate	0.38	0.38		
Personal entrepreneurship			**0.28**	**0.25**
Working climate		0.11		
Internal support structure	0.30	0.30		
Gender		0.08		
Computer experience	0.42	0.42		
ICT attitudes			**0.23**	**0.19**
Working climate	–	0.03		
Internal support structure	–	0.09		
Gender	0.18	0.24		
Computer experience	0.18	0.31		
Personal entrepreneurship	0.30	0.30		
Perceived change			**0.38**	**0.38**
Working climate	–	0.02		
Internal support structure	–	0.06		
Gender	–	0.15		
Computer experience	–	0.19		
Personal entrepreneurship	–	0.19		
ICT attitudes	0.61	0.61		
ICT competence			**0.52**	**0.49**
Working climate	–	0.04		
Internal support structure	–	0.10		
Gender	0.16	0.29		
Age	−0.30	−0.30		
Computer experience	0.30	0.47		
Personal entrepreneurship	0.28	0.33		
ICT attitudes	–	0.17		
Perceived change	0.28	0.28		
Pedagogical approach			**0.16**	**0.12**
Working climate		0.01		
Internal support structure	–	0.04		
Gender	–	0.10		
Age	–	−0.08		
Computer experience	–	0.16		
Personal entrepreneurship	–	0.12		
ICT attitudes	–	0.17		
Perceived change	0.22	0.29		
ICT competence	0.25	0.25		
Innovative use of ICT			**0.43**	**0.40**
Working climate	–	0.05		
Internal support structure	–	0.12		
Gender	–	0.14		
Age	–	−0.01		
Computer experience	0.23	0.45		
Personal entrepreneurship	0.33	0.40		
ICT attitudes	0.18	0.22		
Perceived change	–	0.05		
ICT competence	–	0.05		
Pedagogical approach	0.18	0.18		

computer experience (Beta coefficient: .23) and personal entrepreneurship (Beta coefficient: .33) on innovative use of ICT is stronger than the influence of the teacher educator's pedagogical approach. Furthermore, the

direct influence of the teacher educator's ICT attitude (Beta coefficient: .18) on innovative use of ICT is just as strong as the influence of the teacher educator's pedagogical approach.

The pedagogical approach is directly influenced by the positive changes a teacher perceives in the learning process because of his use of ICT and his ICT competence. Furthermore, there is an indirect effect of ICT attitude on pedagogical approach. Besides the endogenous teacher level factors, the exogenous factor, computer experience, is indirectly related to the pedagogical approach. This indicates that experience with the use of ICT and the changes related to ICT support the development of a student-oriented pedagogical approach. This is consistent with the outcomes of the Apple classroom of tomorrow (ACOT) study (see Haymore Sandholtz et al., 1997).

According to the teachers participating in the case studies changes towards a more student-oriented pedagogical approach and changes towards a more innovative use of ICT often takes place simultaneously and influence each other. By reflecting on the quality of their education, teacher educators are stimulated to develop a more student-oriented pedagogical approach and the matching use of ICT. Consequently, innovative use of ICT is partly the result of a teacher's conscious choice to integrate ICT into their (more student-oriented) education.

4.2. ICT competence

In the past few years, the Dutch government has given much attention to develop and improve the ICT competence of teachers. A lack of ICT competence is often mentioned as an obstacle for the further integration of ICT into education. However, in the model resulting from the PLS analyses, the influence of ICT competence on the innovative use of ICT is limited. There is only a *very small* indirect effect (0.05, see Table 3).

The results of the case studies indicate that teacher educators who use ICT innovatively, develop their competence based on the educational goals they want to accomplish with the help of ICT. Their active attitude and the ICT goals they set for themselves, play an important role in this. This may also explain the positive influence that ICT competence has on the pedagogical approach. It seems that ICT competence is a necessary condition for the use of ICT, but in order to implement innovative use of ICT, other factors are much more important.

4.3. Personal entrepreneurship

The results of the PLS analyses show that the teacher level endogenous factors are especially important for the innovative use of ICT. When the interrelationships between the teacher level factors are studied, 'personal entrepreneurship' turns out to be the key factor for the integration of the innovative use of ICT into the learning process. Within this study, personal entrepreneurship is operationalized as the amount of contacts a teacher educator keeps (both inside and outside the school) for his own professional development in the use of ICT.

The factor personal entrepreneurship influences the innovative use of ICT in different ways (see Fig. 2). First, there is a direct effect of personal entrepreneurship on the innovative use of ICT. Second, personal entrepreneurship indirectly influences the innovative use of ICT through four different chains:

1. Personal entrepreneurship → ICT attitude → Innovative use of ICT
2. Personal entrepreneurship → ICT attitude → Perceived change → Pedagogical approach → Innovative use of ICT
3. Personal entrepreneurship → ICT attitude → Perceived change → ICT competence→ Pedagogical approach → Innovative use of ICT
4. Personal entrepreneurship → ICT competence → Pedagogical approach→ Innovative use of ICT

The chains do not imply that personal entrepreneurship has a meaningful effect on all factors within the chain. It means that by stimulating personal entrepreneurship a large number of processes begin that have a positive influence on the use of ICT. It is comparable to a system of seizing cogwheels. When one cogwheel moves, the other cogwheels will also start moving.

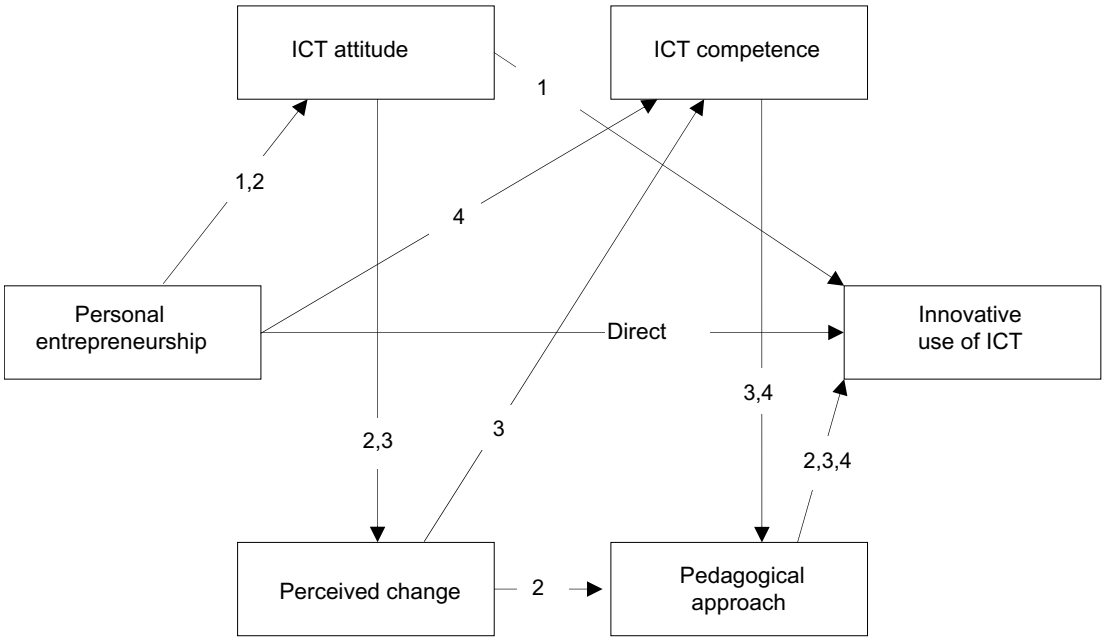

Fig. 2. The interrelatedness of the teacher level endogenous factors.

Spillane (1999) offers a possible explanation for the importance of personal entrepreneurship for the implementation of an innovation in education. In his study of twenty five American high school teachers he found that especially teachers who had in implemented to most significant changes in their teaching the last years, had regular discussions within their schools and with experts. Spillane suggests that teachers, who have a strong engagement towards their own professional development, are more motivated to undertake activities, which lead to a better understanding of the goals of an innovation. By interacting with other colleagues and experts they gain more understanding of the meaning of a change.

Fullan (1992) also argues that, teachers who are actively involved in their own professional development are more able to implement changes in their teaching. Besides the importance of professional contacts, he describes three other teacher characteristics important for the implementation of educational innovations: being able to reflect on their own behaviour, having a research-oriented attitude and having general didactical skills.

The results of the case studies support the importance of personal entrepreneurship for the integration of innovative use of ICT in the learning process. The results of the interviews with the teacher educators show that three of the four teacher educators can be characterized as personal entrepreneurs; they are actively engaging activities, which bring them in contact with other teachers or experts. These contacts help them to evolve their use of ICT. The case studies also show the importance of their reflective and research-oriented attitude which Fullan (1992) mentions. The ability to reflect on their own teaching and their use of ICT helps them to determine the goals they want to reach by integrating ICT within their teaching. In addition, they experiment with different ICT applications to research the value of an ICT application to reach educational goals. The results of the case studies also show that these teachers possessed a strong internal motivation to develop their teaching further; this motivation becomes apparent in initiatives they take to reach their goals. Three of the four teachers have initiated several activities to further develop their use of ICT by joining ICT projects or experimenting with the use of ICT outside regular class hours.

In summary, the case study results and the research literature indicate that the importance of the factor personal entrepreneurship does not solely rely on the professional contacts a teacher keeps for his own professional development. Personal entrepreneurs are not only characterized by their professional contacts but also by their reflective and active behaviour concerning the use of ICT.

4.4. School factors

The school level endogenous factors do not fulfil a meaningful direct effect on innovative ICT-use by teacher educators. However, the results of the PLS analyses show that personal entrepreneurship is strongly influenced by the internal support structure of the school (for instance the support of the management and the ICT coordinator). This means that the internal support structure influences the innovative use of ICT through personal entrepreneurship. The results of the interviewed teacher educators confirm this.

The case studies show that all four teacher educators regard the support of the school as very important for their use of ICT. However, for three of the four teacher educators (the entrepreneurial teacher educators) it is because of their active attitude that they make use of the opportunities offered. Without the availability of support by the school, they would have tried to find the necessary support in other ways. Again, this confirms their 'entrepreneurial innovative' attitude. For their colleagues who do not have the same attitude, the support of the school seems not to be enough to reach the same level of innovative use of ICT. Only one of the interviewed teacher educators indicated that the management of the institute had primarily stimulated his uptake of ICT. The PLS-analyses suggest that this is not common within Dutch teacher education institutes because you would have expected a larger effect from the school level endogenous factors.

5. Conclusions and discussion

The results show that teacher educators who use ICT innovatively in their learning process are characterised by a specific combination of knowledge, skills, attitudes, or competencies that are advantageous for the innovative use of ICT. Looking at all influencing factors, the following profile of this teacher educator can be drawn up:

1. the teacher educator is willing to keep extensive contacts with colleagues and experts in the area of ICT for the sake of his own professional development (personal entrepreneurship),
2. the teacher educator sees and experiences the advantages of the innovative use of ICT in his education (ICT attitude and perceived change),
3. the pedagogical approach of the teacher educator can be described as student-oriented,
4. the ICT competence of the teacher educator complies with his pedagogical approach.

When the results of this study are compared with the study's conceptual framework, it shows that the influence of the school level factors on the endogenous factors at teacher level is consistent with the conceptual framework (see Fig. 1). However, the direct relationship that was expected between the school level endogenous factors and the implementation outcome is not supported by the data. When the implementation outcome is considered a product of a change process, the teacher educator has the most influence on the quality and the characteristics of the product: innovative use of ICT.

Personal entrepreneurship turns out to be the anchor point for stimulating the innovative use of ICT in education. The teacher educators characterised as 'personal entrepreneurs' in this study, created possibilities to experiment with ICT applications, researched the use of ICT in their education, reflected on their outcomes, and exchanged ideas with colleagues Although 'personal entrepreneurship' is mainly an attitudinal characteristic of an individual teacher, teacher education institutes should create favourable conditions that support personal entrepreneurship. This study showed that the support of the school plays a role in stimulating the personal entrepreneurship of the teacher educator. Personal entrepreneurship can be seen as the catalyst between the endogenous factors on the teacher level and the endogenous factors on the school level. In other words, even though the teacher level factors fulfil a key role in the realisation of innovative use of ICT, the results also show that the school's support can make an important contribution. This is especially true for the support and stimulation of personal entrepreneurship.

Supportive conditions for personal entrepreneurship could be (see Drent, 2005):

- the development of cooperative communities between teachers;
- the stimulation of reflective behaviour with teacher educators towards their own activities;

- the freeing-up of time and creation of facilities to experiment with innovations.

The question remains whether the implementation of innovative ICT-use should be primarily a bottom up or a top down process. Stimulating bottom up initiatives means that a strong emphasis is placed on the professionalism and personal preferences of individual teacher educators. As comes forward in literature on educational innovations (e.g., Fullan, 2001), both bottom up as top down initiatives are necessary for the successful implementation of an innovation. Therefore, although the PLS analyses do not show a direct effect between the school level factors and the implementation outcome, it seems to be also relevant that teacher education institutes do not only stimulate the 'bottom up' integration of innovative ICT-use, but also stimulate 'top down' integration of innovative ICT-use.

This study has made use of the PLS technique. The PLS technique is especially developed for explorative research, as was the case in this study. A limitation of this technique is that it does not include a significance test. To validate the developed model, other confirming analysis techniques are necessary. Furthermore, more attention should be given to the school level factors. In this study, they are measured based on the individual perception of teacher educators. More insight into the influence of these factors can be acquired by measuring them at the school's level. Analysis techniques like multilevel analysis, therefore, provide a logical approach for a follow up to this study.

References

Afrassa, T. M. (1999). Mathematics achievement at the lower secondary school stages in Australia and Ethiopia: A comparative study of standards of achievement (doctoral dissertation). Melbourne: Flinders University.

Becker, H. J. (2000). Findings from the teaching, learning, and computing survey: Is Larry Cuban right? *Education Policy Analysis Archives*, 8, 51. Retrieved online 15 July, 2006, from http://epaa.asu.edu/epaa/.

Bos, K., & Kuiper, W. (1999). Modelling TIMSS data in a European comparative perspective: Exploring influencing factors on achievement in Mathematics in Grade 8. *Educational Research and Evaluation, 5*(2), 157–179.

British Educational Communications and Technology Agency [BECTA] (2004). *A review of the research literature on barriers to the uptake of ICT by teachers*. Retrieved online February, 25, 2005 at www.becta.org.uk/page_documents/research/barriers.pdf.

ten Brummelhuis, A. C. A. (1995). *Models of educational change: The introduction of computers in Dutch secondary education* (doctoral dissertation). Enschede: University of Twente.

ten Brummelhuis, A. C. A. (2001). *ICT-monitor 1999–2000, lerarenopleidingen [ICT-monitor 1999-2000 Teacher education]*. Enschede: University of Twente.

Campbell, J. R. (1996). *PLSPATH primer* (2nd ed.). New York: St. John's University.

Drent, M. (2005). *In transitie: Op weg naar innovatief ICT-gebruik op de PABO* [In transition: On the road to innovative use of ICT in teacher education] (doctoral dissertation). Enschede: University of Twente.

Ely, D. P. (1999). Conditions that facilitate the implementation of educational technology innovations. *Educational Technology, 39*(6), 23–27.

Falk, F. R. (1987). *A primer for soft modelling*. Berkeley: Institute of Human Development, University of California.

Fullan, M. R. (1992). *Successful school improvement: The implementation perspective and beyond*. Birmingham: Open University Press.

Fullan, M. G. (2001). *The new meaning of educational change*. New York: Teachers College Press.

Grunberg, J., & Summers, M. (1992). Computer innovation in schools: A review of selected research literature. *Journal of Information Technology for Teacher Education, 1*(2), 255–276.

Haymore Sandholtz, J. H., Ringstaff, C., & Dwyer, D. C. (1997). *Teaching with technology: Creating student-centered classrooms*. New York: Teachers College Press.

Janssen Reinen, I. A. M. (1996). *Teachers and computer use: The process of integration IT in the curriculum* (doctoral dissertation). Enschede: University of Twente.

Jonassen, D. H. (2000). *Computers as mindtools for schools: Engaging critical thinking*. Upper Saddle River, NJ: Merrill.

Ministry of Education, Culture and Science (1999). *Maatwerk voor Morgen: het perspectief van een open arbeidsmarkt* [Adjustments for tomorrow, perspectives on an open job market]. Retrieved online 15 January, 2003, at http://www.minocw.nl/werkinonderwijs/publicaties.html.

Ministry of Education, Culture and Science (2002). Onderwijs on line: eindrapportage [Education on line, final report. Retrieved online January 15, 2004, at http://www.minocw.nl/ict/publicaties.html.

Mumtaz, S. (2000). Factors affecting teachers' use of information and communication technology: A review of the literature. *Journal of Information Technology for Teacher Education, 9*(3), 319–341.

Niederhauser, D. S., & Stoddart, T. (2001). Teachers' instructional perspectives and use of educational software. *Teaching and Teacher Education, 17*, 15–31.

Pelgrum, W. J. (2001). Obstacles to the integration od ICT in education: Results from a worldwide educational assessment. *Computers and Education, 37*, 163–178.

Pelgrum, W. J., Janssen Reinen, I. A. M., & Plomp, T. (1993). *Schools, teachers, students and computers: A cross-national perspective*. Den Haag: IEA.

Pelgrum, W. J., & Plomp, Tj. (2005). *SITES-2006: Conceptual framework and research design*. Enschede: University of Twente.

Perkins, D. N. (1993). Person-plus: A distributed view of thinking and learning. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations* (pp. 88–110). Cambridge, UK: Cambridge University Press.

Plomp, Tj., ten Brummelhuis, A. C. A., & Rapmund, R. (1996). *Teaching and learning for the future*. Report of the Committee on MultiMedia in Teacher Training (COMMITT). Den Haag: SDU.

Pulos, S., & Rogness, N. (1995). Soft modeling and special education. *Remedial and Special Education, 16*(3), 184–192.

Sellin, N. (1989). An overview of Partial Least Squares (PLS) analysis. In L. W. Anderson, D. W. Ryan, & B. J. Shapiro (Eds.), *The IEA classroom environment study*. Oxford: Pergamon Press.

Sellin, N. (1990). *PLSPATH, version 3.01 application manual*. Hamburg: University of Hamburg.

Sellin, N., & Keeves, J. P. (1994). Path analysis with latent variables. In T. Husén & T. N. Postlethwaite (Eds.), *The international encyclopedia of education (blz. 4352–4359)*. Oxford: Pergamon Press.

Sellin, N., & Keeves, J. P. (1997). Path analysis with latent variables. In J. P. Keeves (Ed.), *Educational research, methodology, and measurement: An international handbook (blz. 633–640)* (2nd ed.). Oxford: Pergamon Press.

Spillane, J. P. (1999). External reform initiatives and teachers' efforts to reconstruct their practice: The mediating role of teachers' zones of enactment. *Journal of Curriculum Studies, 31*(2), 143–175.

Van den Dool, P. C. (2003). *Professioneel onderwijspersoneel: opleiden met de school, tweede evaluatie van educatief partnerschap* [Professional teaching personel: Educating with the school, second evaluation of 'educatief partnerschap']. Utrecht: Inspectie van het onderwijs.

Voogt, J. (2003). Consequences of ICT for aims, contents, processes and environments of Learning. In J. van den Akker, W. Kuiper, & U. Hameyer (Eds.), *Curriculum landscapes and trends (blz. 217–236)*. Dordrecht: Kluwer.

Voogt, J. M. & Odenthal, L. E. (1997). *Emergent practices geportretteerd: Conceptueel raamwerk* [Emergent practices portrayed]. Enschede: University of Twente.