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Gender differences in computer attitudes: Does the school matter?

Martina R.M. Meelissen [a,*], Marjolein Drent [b]

[a] *Department of Educational Organization and Management, Faculty of Behavioral Science, University of Twente, Drienerlolaan 5, 7522 NB Enschede, The Netherlands*
[b] *Department for Information Technology, Library and Education (ITBE), University of Twente, Drienerlolaan 5, 7522 NB Enschede, The Netherlands*

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Abstract

In most western countries, the participation of females in ICT professional careers is not only low but is also still falling [Anderson, N., Lankhear, C., Timms, C., & Courtney, L. (in press). Because it's boring, irrelevant and I don't like computers': Why high school girls avoid professionally-oriented ICT subjects. *Computers* & *Education*.]. Policy makers as well as researchers often assume that the interest of girls in computing and ICT-professions could be increased at school. For example, female teachers who are confident ICT-users, are expected to act as positive role models for girls. However, because most of the research on gender and computing has been focussing on the influence of none-school related factors, there is little empirical evidence that schools or teachers are able to influence girls' attitude toward ICT. Using the data of a Dutch large-scale survey on ICT use in primary education (almost 4000 grade 5 students), this study explores the influence of both none-school related factors and school related factors on students' computer attitude. Although the between-school variance of girls' computer attitude is higher than that of boys' computer attitude, multilevel analyses show that most of the variance in computer attitude is explained by none-school related student factors. Two school related factors turned out to have a small positive effect on the computer attitude of girls: a teacher-centred pedagogical approach and the computer experience of female teachers.

Keywords: Gender differences; Computer attitudes; Primary education

* Corresponding author. Tel.: +31 534893668; fax: +31 534893791.
E-mail address: meelissen@edte.utwente.nl (M.R.M. Meelissen).

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1. Introduction

Research on gender differences in ICT has shown that in most countries (including the Netherlands) girls and women are often behind in ICT use and ICT knowledge and skills. In most western countries, the participation of females in ICT professional careers and pathways is not only low but is also still falling (Anderson, Lankhear, Timms, & Courtney, in press). In the Netherlands, about 10% of the employees working in ICT-related jobs are female. Furthermore, girls and women have less positive attitudes toward ICT and show less confidence in using ICT compared to boys and men (e.g. Beentjes, Vooijs, & Kruse, 1995; Rozell & Gardner, 2000; SCP, 2003; Shashaani, 1994b). Although not supported by convincing empirical evidence, girls' less positive attitude to ICT in primary and secondary school is often regarded as predictor of and explanation for the low participation of women in ICT training and ICT related professions (Portegijs, Boelens, & Keuzenkamp, 2002; Turner, Bernt, & Pecora, 2002).

Both policymakers and researchers on gender differences and ICT have high expectations of schools and teachers to make ICT more attractive for girls (e.g. Comber, Colley, Hargreaves, & Dorn, 1997; McIlroy, Bunting, Tierney, & Gordon, 2001; Ministry of Education, Culture & Sciences, 1998). For example, teachers are expected to select and use educational software attractive to both girls and boys. Also, there are high expectations for female teachers who are confident with ICT: they are seen as role models for female students (e.g. Cooper & Waever, 2003).

However, until now there is little empirical evidence that these *school related factors* have any impact on girls' attitudes toward ICT. During the last 25 years, a lot of research has been carried out on gender differences and attitudes toward ICT (which in most studies is referred to as 'computer attitude'). Although the results of these studies are far from unambiguous, most research shows that gender differences in computer attitudes are related to *non-school related factors*. Factors that are mentioned in these studies are computer experience, accessibility of computers at home, computer skills, the 'masculine' image of computers, and parents' computer use and attitudes (e.g. Brosnan, 1998; Kadijevich, 2000; Shashaani, 1994a). The effects of school related factors (characteristics of schools, teachers and instructional characteristics) on students' computer attitude have hardly been studied (Mumtaz, 2001; Volman, 1997).

This was the reason for conducting an exploratory study on the influence of non-school related factors in conjunction with school related factors, on students' computer attitude. Explorations were conducted on data from the *ICT-monitor*, a Dutch large-scale survey on the implementation of ICT in primary, secondary, and vocational education (including teacher training, e.g. Brummelhuis, 1998). The ICT-monitor started in 1997 and has been repeated every year since to evaluate the effects of the educational policy that stimulates the use of ICT in education.

National reports on the ICT-monitor have shown a substantial diversity among schools in the way ICT is implemented and used for educational purposes (Brummelhuis & Drent, 2000). In this study, this diversity was assumed to lead to a variety of different computer attitudes of students. In other words, it was expected that schools (and teachers) 'matter' with regard to students' computer attitude. The problem statement of this study is as follows:

> To what extent do school related factors (characteristics of schools, classes, and teachers) influence differences in computer attitude among students—particularly between girls and boys—in grade 5, primary school, given the influence of non-school related characteristics?

The Dutch Education Council (2000) has advised that school and teachers should influence students' computer attitude at the youngest age possible. Therefore, this exploration has been carried out on the ICT-monitor data collected in grade 5 of primary schools (10 and 11 year-olds).

2. Conceptual model

The conceptual model of this study is based on the model of the structure of concentric circles developed by Veenstra (1999). This model has originally been developed for the analysis of students' achievement, but proved to be an appropriate framework for this study as well (Meelissen, 2005).

It consists of two structures of concentric circles: one on the student level and one on the school/teacher level (see Fig. 1). The innermost circle of the *student model* refers to the dependent variable, which in this case is students' computer attitude. The outermost circle on the student level includes (non-changeable) structural characteristics, like students' gender. The characteristics of 'family interactions' (e.g. parents' use of computer, encouragement by parents to use computers) as well as cultural student characteristics (e.g. out-of-school computer use, availability of computer(s) at home) are placed as intermediate variables between the outermost and core circle.

The structure of concentric circles on the *school/class* level is almost similar to the student model. The outermost circle consists of contextual (non-changeable) characteristics (e.g. demographic characteristics of the school) followed by cultural school characteristics (e.g. ICT-policy, pedagogical approach), structural teacher characteristics (e.g. gender, teaching experience, computer experience), and cultural teacher characteristics (e.g. teaching style, use of ICT in the classroom).

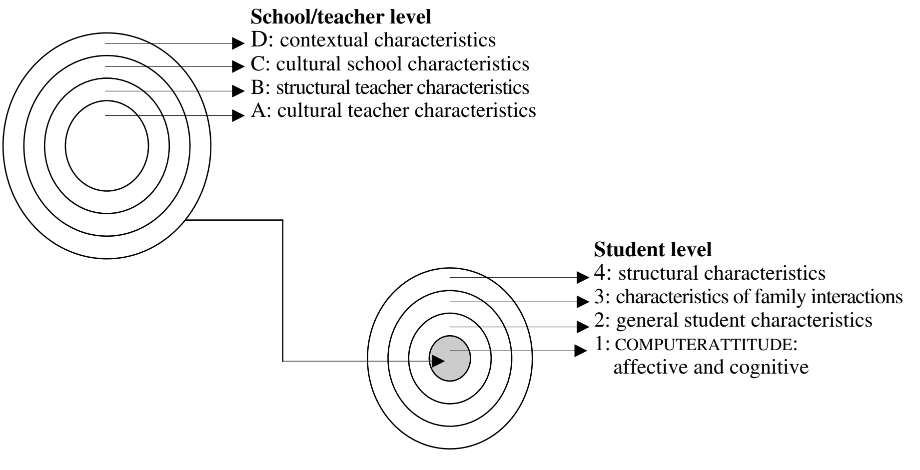

Fig. 1. Conceptual model of this study, based on the structure of concentric circles by Veenstra (1999).

For the development of the conceptual model, factors identified by a literature survey were classified by the extent to which they are directly related to students' computer attitudes or may be changeable by other factors (see Table 1).

3. Method

The analyses have been conducted on the data of the ICT-monitor of 1999. In the ICT-monitor, information on the use of ICT for educational purposes, as well as background information has been collected by means of school, teacher, and student questionnaires. The selection of schools is based on a random sample. The data set consists of 209 schools and 3893 students (1987 girls and 1906 boys). Non-response analysis revealed that the participating schools do not differ from the non-participating schools with regard to frequency of ICT-use and schools' demographic characteristics. Therefore, the results of this study can be regarded as representative of the research population (Brummelhuis & Drent, 2000).

The influence of student, teacher, and school factors on students' computer attitude has been explored by means of multilevel analysis. With this technique it is possible to explore the effects of factors on the dependent variable on different levels. In the ICT-monitor, students (the first level) were nested in schools/classes (the second level: for each school one grade 5 class participated in the study). Multilevel analysis takes into account this nested design of the data without the necessity to aggregate or disaggregate the data in order to relate variables of different levels with each other. One of the major advantages of multi-

Table 1
Overview factors analysed in this study

Concentric circle	Factor
Student level	
4: Structural students' characteristics	Gender
3: Characteristics of family interactions	Computer use parents; perceived encouragement by parents to use computer; rules at home regarding computer use
2: General student characteristics	Gender stereotyped views on computers ($\alpha = .50$)[a]; self-efficacy in computer use ($\alpha = .88$); frequency and variety ($\alpha = .66$) of computer use outside school hours; availability (own) computer at home; equipment of computer at home ($\alpha = .84$)
1: Dependent variable	Computer attitude ($\alpha = .80$)
School/teacher level	
D: Contextual school characteristics	Class and school size; religious/educational ideology, student–computer ratio; average student-weight (% students from low social economic backgrounds)
C: Cultural school characteristics	Pedagogical approach ($\alpha = .85$); equal opportunity policy regarding ICT; computer attitude of the teaching staff; use of external ICT support ($\alpha = .67$); ICT co-operation with others schools ($\alpha = .67$)
B: Structural teacher characteristics	Gender; teaching experience; computer experience
A: Cultural teacher characteristics	Perceived lack of ICT knowledge and skills ($\alpha = .79$); perceived expertise in ICT; intensity of ICT use for educational purposes; variety of ICT use for educational purposes ($\alpha = .55$); perceived benefits of ICT for teaching ($\alpha = .76$); teaching style ($\alpha = .79$); use of ICT-support ($\alpha = .55$)

[a] Alpha is presented for each scale consisting of three or more items.

level analysis over unidimensional (regression) analysis, is that it estimates the effects of variables on the dependent variable at one level (student level) taking into account the effects of variables on the dependent variable at another level (school/teacher level) at the same time. A multilevel technique based on traditional multiple regression is regarded as most suitable for the exploration of data (Maeyer & Rymenans, 2004). In this study, MlwiN has been used (Institute of Education, 2000).

In preparation of the multilevel analysis, the data of the ICT-monitor have been explored to find items or sets of items which are operationalisations of factors identified in the literature survey. The internal consistency of a set of items representing a scale (factor) was determined with the standardised Cronbach α (the α of each scale is presented in Table 1). The lower bound for the Cronbach α to keep a scale was .50. Table 1 shows that the α of most scales are above .60.

With regard to the computer attitude scale (the dependent variable in this study), the literature survey indicated a distinction in three components: an affective component (pleasure in using computers); a cognitive component (perceived relevance of computers); and a conative component (anxiety and self-confidence, e.g. Christensen & Knezek, 2000; Fishbein & Ajzen, 1975). In the ICT-monitor, students were asked if they (dis)agreed or (dis)-agreed a lot (on a four-point scale) with 11 statements (one of these items was negatively formulated) with regard to their computer attitudes. These items only refer to the affective component (five items, $\alpha = .73$) and cognitive component (six items, $\alpha = .69$). Furthermore, it is also possible to make a second distinction in components: items referring to computer use at school (five items, $\alpha = .65$) and items referring to computer use in general (six items, $\alpha = .71$, see Table 2). The principal component analysis does not clearly show

Table 2
Computer attitude of girls and boys in primary education ($n = 4361$)

	M (SD) (scale: 0–100)[a]		
	Girls	Boys	Total
Attitude toward computer use at school[b]	73 (17)	80 (16)	76 (17)
I enjoy lessons in which computers are used (A)	77 (24)	80 (25)	78 (24)
I would like to use the computer at school more often (A)	75 (28)	80 (27)	77 (28)
Computers can help me to learn things more easily (C)	73 (26)	80 (26)	77 (26)
I know that I can learn many new things from computers (C)	71 (26)	80 (25)	75 (26)
All students should learn about computers at school (C)	70 (27)	78 (26)	74 (27)
Attitude toward computers in general[b]	66 (17)	79 (16)	72 (17)
I want to know a lot about computers (A)	60 (30)	79 (27)	70 (30)
Computers do not interest me very much (A)[c]	73 (28)	85 (25)	79 (27)
I like talking about computers with others (A)	50 (28)	72 (27)	61 (30)
You can do a lot of things with computers (C)	82 (22)	88 (22)	85 (22)
You benefit a lot from knowing how to use computers (C)	82 (21)	88 (19)	85 (21)
If you can use computers, you will get a better job in the future (C)	50 (31)	61 (32)	56 (32)
Total computer attitude scale	69 (15)	79 (14)	74 (15)

[a] The answers were transferred to a score between 0 and 100: the higher the score the more positive the attitude; significance of differences between the two groups is calculated with Students' t-test, all differences between the groups are significant ($p = .00$).
[b] A = affective component, C = cognitive component.
[c] Negative statement: scale from 0 (totally agree) to 100 (totally disagree).

which distinction in components is more appropriate. The internal consistency of both distinctions in components is acceptable, but the total scale, including all 11 items is more consistent ($\alpha = .80$, the values of the negative statement were reversed, in order to maintain a unified direction of the scale). Therefore, the multilevel analysis has been conducted with the total computer attitude scale as the dependent variable.

A selection of relevant influencing factors was made based on Pearson product–moment correlations of these factors with the students' scores on the computer attitude scale (criterion: $r \geqslant 0{,}15$, $p < .01$). Because data on computer attitude was collected on a different level (student level) than school and teachers factors, the Pearson product–moment correlations were calculated for the student factors only. Consequently, all school and teacher factors identified in the literature survey and available in the ICT-monitor, were included in the explorative analyses. Table 1 provides an overview of all factors selected for the explorative analyses.

The first model which was analysed with MlwiN, is the fully unconditional or empty model. In this model no potentially influencing factors are included yet. The model only indicates how much of the variance in computer attitude can be "explained" by differences between individual students or by differences between school/classes. What these differences are (or which student factors and school/teacher factors are important) is determined by the following multilevel models.

The conceptual model of this study has guided these following multilevel models. As stated earlier, student, teacher and school factors in this model are arranged in circles to the extent to which they are directly related to students' computer attitudes (see Fig. 1). For each next multilevel model, the effects on computer attitude of all student factors within one circle have been analysed, starting with the outermost circle. Before entering all the factors of the next circle at the same time, factors with non-significant effects are deleted from the model first. The same procedure has been followed for the school and teacher factors. By doing so, the otherwise very complex explorative analyses and interpretation of the results are simplified (Veenstra, 1999).

Another way to simplify the analyses and interpretations of results was to split the data into a data set for girls and a data set for boys and to analyse the data sets separately. Opposed to analysing the interaction effects of gender with each potentially influencing factor, the separate analyses makes it easier to identify factors important for the computer attitude of girls and factors important for the computer attitude of boys (Houtte, 2002). Based on the results of the separate analyses, multilevel analyses have also been conducted on the complete data set.

Tables 2 and 3 give an overview of gender differences in computer attitudes and in relevant non-school related student factors (significance of these differences is tested with Students' t-test). Table 4 presents the final multilevel model in which only factors (on student and school/class level) with a significant effect on computer attitude are included. All the in-between models that were analysed can be found in Meelissen (2005). Table 5 provides a summary in terms of the proportion of the variance in computer attitude that has been explained by adding influencing factors in the models. First, it presents the variance (that need to be explained) for the empty model without any influencing factors. Next, the explained proportion of variance of the student model (only student factors with a significant effect) and the explained proportion of variance in the final model (all factors, including school and class characteristics with a significant effect) are presented.

Table 3
None-school related student characteristics of girls and boys in primary schools ($n = 4361$)

	Girls *M* (SD)	Boys *M* (SD)	Total *M* (SD)
Characteristics of family interactions			
Computer use mother at home (1 = never, 2 = sometimes, 3 = often)	1.8 (.07)	1.8 (.07)	1.8 (.07)
Computer use father at home (1 = never, 2 = sometimes, 3 = often)	2.3 (.08)	2.2 (.08)	2.2 (.08)
Perceived encouragement by parents to use computer (0–100)[b]	36 (26)	45 (27)[a]	40 (27)
General students' characteristics			
Gender stereotyped views on computers (0–100)[c]	35 (28)	52 (31)[a]	43 (31)
Self-efficacy in computer use (0–19 computer activities)	6.5 (3.8)	8.4 (4.7)[a]	7.5(4.4)
Frequency computer use outside school hours (hours per week)	2.9 (3.5)	5.0 (5.0)[a]	4.0 (4.5)
Variety of computer use outside school hours (0–9 ICT applications)	4.3 (1.9)	4.3 (2.1)	4.3 (.94)
Equipment computer(s) at home (0–11 characteristics)	5.2 (2.9)	5.9 (3.0)[a]	5.6 (3.0)

[a] Significant difference between boys and girls ($p = .00$, significance of differences between the two groups is calculated with Students' t-test).
[b] Scale of two items ($r = .48$, $p < .00$); the higher the score the more encouragement students perceive.
[c] Scale of four items referring to the 'masculinity' of computers; a high score refers to strong gender stereotyped views.

Table 4
Final estimation of fixed effects in 2-level model on computer attitudes, of girls, boys and total, from 209 schools (standardised data)

Fixed effects	Final model (student and school/teacher characteristics)		
	Girls ($n = 1987$) Coefficient (SE)	Boys ($n = 1906$) Coefficient (SE)	Total ($n = 3893$) Coefficient (SE)
Intercept	.016 (.028)	.008 (.024)	.227 (.023)
Structural students' characteristics			
'Girl' (gender)	n.a.	n.a.	−.411 (.028)
Characteristics of family interactions			
Perceived encouragement by parents to use computers	.348 (.021)	.344 (.021)	.302 (.019)
General student characteristics			
Self-efficacy in computer use	.100 (.020)	.077 (.028)	.073 (.017)
Frequency computer use outside school hours	.154 (.020)	.157 (.022)	.144 (.015)
Variety of computer use outside school hours	–	.069 (.026)	.064 (.017)
Equipment computer at home	–	.078 (.026)	n.s.
Interaction effects			
'Girl' * encouragement parents	n.a.	n.a.	.112 (.026)
'Boy' * equipment computer at home	n.a.	n.a.	.066 (.021)
Group effects			
Group average perceived encouragement by parents to use computers	.159 (.067)	n.s.	n.s.
Contextual school characteristics			
Average student-weight	.076 (.030)	.079 (.028)	.090 (.020)
Cultural school characteristics			
Pedagogical approach	−.055 (.027)	n.s.	−.047 (.019)
Interaction effects			
'Female teacher' * computer experience teacher	.072 (.029)	n.s.	n.s.
'Girl' * 'female teacher' * computer experience teacher	n.a.	n.a.	.066 (.023)
Random effects	Var. component (SE)	Var. component (SE)	Var. component (SE)
School	.067 (.014)	.035 (.011)	.035 (.007)
Students	.663 (.022)	.727 (.025)	.631 (.015)
Deviance	4958.726#	4875.259#	9402.688#

Notes. For all fixed effects included in the final model, t-value > 1.96 (this resembles a confidence interval of 95%); n.s. = not significant, not included in the final model; n.a. = not applicable; # = the difference between the deviances of student model (only student factors) is significant ($p < .001$).

Table 5
Explained proportion of variance, final model for girls, boys and total

Variance	Girls			Boys			Total		
	Model 0	Student model[a]	Final model	Model 0	Student model[a]	Final model	Model 0	Student model[a]	Final model
School	.143 (14%)	.077	.067	.057 (6%)	.040	.035	.070 (7%)	.041	.035
Explained proportion of variance	–	39%	44%	–	26%	30%	–	38%	44%
Student	.864 (86%)	.667	.663	.943 (94%)	.727	.727	.931 (93%)	.632	.631
Explained proportion of variance	–	26%	28%	–	23%	24%	–	33%	33%

[a] Model including only student factors (structural characteristics, characteristics of family interactions and general student characteristics) with a significant effect on computer attitude.

4. Findings

4.1. None-school related factors: gender (circle 4)

Based on his meta-analysis of English and American studies on gender differences and computer attitudes, Whitley (1997) concludes that in general, females have less positive computer attitudes than males, but their attitudes toward computers are rarely negative. The current study is consistent with his findings: both boys and girls in grade 5 have positive attitudes toward computers, but boys are even more positive than girls are (Table 2). The statements referring to 'computers in general' show the most substantial gender differences. Gender differences in attitude toward the statements referring to 'computer use at school' are small or negligible.

As stated earlier, the starting model of the multilevel analysis is the so-called 'empty model'. In this model, no potentially influencing student, school, or teacher factors are included. The empty model demonstrates that for girls, the variance in computer attitude between schools is 14% and between students 86% (see Table 5, model 0). For boys the between-school variance in computer attitude is only 6%, which means that most of the variance in computer attitudes of boys can be explained by differences between boys (94%). In other words, it seems that the school/class 'matters' more for girls' computer attitude than for boys' computer attitude.

4.2. None-school related factors: family interactions (circle 3)

Researchers supporting the so-called 'socialisation theory', regard the social environment of a child as the main factor influencing gender differences in computer attitudes and use. Parents especially, are assumed to play a substantial role in the development of their childrens' attitude toward computers (e.g. Colley, Gale, & Harris, 1994). Grade 5 students in the current study report that their father uses the computer at home more frequently than their mother (Table 3). However, the multilevel analysis shows that the computer use at home by parents does not influence the computer attitudes of their sons or daughters.

The extent to which students experience encouragement by their parents to use and learn about computers turns out to be an important factor with regard to the computer attitudes of students. In the final multilevel model (presented in Table 4) the factor 'perceived encouragement by parents' shows the strongest significant effect on the computer attitude of girls as well as that of boys (.30). It appears that the more encouragement from parents to use computers, the more positive their attitudes are toward computers. Although boys experience more encouragement from their parents than girls do (Table 3), the effect of encouragement by parents seems even a little stronger for girls' computer attitude (.35) than boys' computer attitude (.34) (Table 4). In other words, gender differences in computer attitude seem to be related to gender differences in students' perceived encouragement by parents in computing.

4.3. None-school related factors: general student characteristics (circle 2)

There is some empirical evidence that gender-stereotyped views on computers are related to gender differences in computer attitude (Shashaani, 1993). The scores on this scale in the ICT-monitor (consisting of four items referring to the 'masculinity' of computers) reveal substantial differences between girls and boys (Table 3). More boys than girls have gender stereotyped views of computers. The majority of boys in grade 5 are convinced that boys know more about computers than girls do; about a third of the girls agrees with them. Girls with less gender-stereotyped views on computers were expected to have more positive computer attitudes. However, gender stereotyped views on computers turned out to be not related to girls' and boys' computer attitude.

For both boys and girls the intensity of computer use (.14) and self-efficacy in computer use (.07) have a positive effect on their computer attitude (Table 4). Boys report considerably more frequent computer use outside school hours (on average 5 h per week) than girls do (on average 3 h per week, Table 3). Compared to girls, boys also judge their self-efficacy in computer use (the number of ICT-activities a student can perform independently) more positively, especially with regard to the use of email and the Internet. There are not only significant gender differences in self-efficacy, but also in the use of ICT-applications. Outside school hours, more boys than girls use email and the Internet, while more girls than boys use the computer for drawing and word-processing. The multilevel analysis indicates that the variety of computer use outside school hours (number of used ICT applications) has a small positive effect on the computer attitude of boys (.07) but not on that of girls (Table 4).

In the conceptual model of this study, general student characteristics discussed in this section are regarded as factors that influence computer attitudes. However, it is also plausible that the influence of these factors on computer attitude is reciprocal. For example, the more positive the computer attitude of a student, the more interested he or she will be in using computers and trying (new) ICT applications, resulting in an even more positive attitude toward computers. Because girls show lower intensity and lower self-efficacy in computer use than boys, these reciprocal relations may increase gender differences in computer attitudes in the long term. In other words, gender differences in computer attitude may increase with age. Although not all studies have found a relationship between age and computer attitude (Fletcher-Flinn & Suddendorf, 1996; King, Bond, & Blandford, 2002), the ICT-monitor does show more extensive gender differences in computer attitude of students in secondary education (grade 8) than in primary education (Brummelhuis & Slotman, 2000). The research of Comber et al. (1997) accords with this assumption. Interest and self-efficacy in computers of girls decrease with age, while the interest and self-efficacy in computers of boys stay the same. Based on a meta-analysis of gender and computer studies, Chua, Chen, and Wong (1999) also conclude that gender differences in computer anxiety (girls being more anxious toward the use of computers than boys) increase with age.

4.4. School-related factors: contextual school characteristics (circle D)

After including the none-school related characteristics in the model, the effects of school-related characteristics on computer attitude have been analysed. Circle by circle, the effects of contextual characteristics, cultural characteristics, structural teacher characteristics, and cultural teacher characteristics on computer attitude have been explored.

Of all the contextual school characteristics analysed in this study—religious ideology or educational ideology of the school, number of students in the school and in the class, student–computer ratio and ‘average student-weight’—only the latter shows a significant effect on students’ computer attitude (.09, Table 4). The average student-weight refers to schools’ average number of native and non-native students (of non-western countries) from low social economic backgrounds. Dutch schools receive extra financial governmental support for these students.

It appears that students from schools with a higher average student-weight are more positive toward computers than students from schools with a lower average student-weight. This may suggest that on the student level, computer attitude and social economic background are related. However, this assumption can not be confirmed because the ICT-monitor data provide no information on students’ social economic background on individual level.

4.5. School-related factors: cultural school characteristics (circle C)

The pedagogical approach of the school turns out to be the only cultural school characteristic that has a small effect on students’ computer attitude (−.05). For boys, the pedagogical approach of the school has no influence on their computer attitude. However, girls from schools with a mainly student-oriented pedagogical approach appear to have less positive computer attitudes compared to girls from schools with a mainly teacher-centred pedagogical approach (−.06, Table 4). A student-oriented pedagogical approach (individual approach and self-learning by students) is assumed to be in contrast to a teacher-centred pedagogical approach, in which the teacher fully controls the learning process and instruction can be characterised as whole-class teaching (Brummelhuis, 1998). In a student-oriented learning environment, students are given more responsibility in organising their own learning activities. Therefore, they may also have more freedom in deciding if and how they use the computer during lessons. This study has already shown that outside school, boys use the computer more frequently than girls. The ICT-monitor does not provide data on students’ computer use in the school, but it seems likely that in such a learning environment, girls may also use the computer less often than boys during lessons. These differences in use may be related to the effect of schools’ pedagogical approach on girls’ computer attitude.

4.6. School-related factors: structural and cultural teacher characteristics (circle B and A)

The effects of three structural teacher characteristics on students’ computer attitude have been explored: gender, teaching experience, and computer experience. None of those characteristics seem to be related to students’ computer attitude. However, if the teacher is female, the computer experience of the teacher has a small effect on girls’ computer attitude (.07, Table 4). This significant interaction effect accords with the ‘role model theory’. This theory assumes that female teachers who are confident in using ICT can enhance the attractiveness of computers for girls (e.g. Brosnan, 1998). Based on this theory, an interaction effect between girls’ computer attitude and the perceived ICT knowledge and skills of a female teacher was also expected in this study. However, the ICT knowledge and skills perceived by female teachers turned out to be not related to the computer attitude of girls.

What this study does show is that female teachers assess their knowledge and skills in ICT considerably less positively than male teachers do. For example, only a third of the teachers who indicate that they are well informed about the possibilities of ICT for educational use (only a quarter of all teachers) is female. These gender differences are absent for teachers' intensity and variety (number of different ICT applications) of computer use in the classroom. In other words, although female teachers show the same intensity and the same variety in ICT use for educational purposes, they are less convinced about their ICT knowledge and skills than their male colleagues are.

Neither the intensity nor the variety of teachers' ICT use for educational purposes show an effect on the computer attitude of students. Also, the remaining cultural teachers' characteristics, appear not to be related to the computer attitude of their students. In studies on gender and computers it is suggested that innovative and challenging use of ICT for educational purposes as well as teachers' attitude toward ICT and the teachers' teaching style are related to the use and attitudes of students toward computers (e.g. Mumtaz, 2001). The absence of significant effects of the cultural teacher characteristics in the current study seems to be in contrast to these expectations. However, the conclusion that these characteristics are not important for students' computer attitude may be premature. The teacher characteristic 'variety of ICT use' in the ICT-monitor refers to the number of different learning activities for which ICT is used. In most cases this 'variety' is limited to drill and (extra) practice, remedial teaching and word processing. These uses of ICT are hardly innovative or very challenging for students, especially compared to students' ICT activities outside school. In this study, based on data of '99, innovative uses of ICT, like ICT supported problem solving or exploring new topics, hardly occur in grade 5.

Furthermore, the factor 'perceived benefits of ICT use for teaching' is a limited operationalisation of teachers' computer attitude. It provides no information about teachers liking ICT, their self-confidence in ICT use, or gender-stereotyped views on ICT. The latter especially seems to be of interest as Dutch research indicates that only a small majority of teachers are convinced that boys and girls perform equally well while working with computers (Portegijs et al., 2002). Almost half of the teachers expect boys to perform better.

Teachers' teaching style is also operationalised on a limited scale in the ICT-monitor. Most items of this scale refer to the extent a teacher takes into account the differences between students in learning abilities. The ICT-monitor provides no information about how the teacher deals with gender differences in learning styles or in the use of and attitudes toward ICT.

In Table 5, the explained proportion of variance by student and school/class factors in de final models (girls, boys and total) is presented.

The table shows that the student factors (structural characteristics, characteristics of family interactions and general student characteristics) explain 38% of the total variance (7%) on school level (total model). Only 6% of the total variance on school level is explained by school and teacher characteristics. Furthermore, in the final model only a third of the variance on student level is explained by factors included in the analyses.

Because the ICT-monitor is not designed for studying gender differences in computer attitude, some of the potentially influencing factors on computer attitude are not available or limited operationalised. The main objective of the ICT-monitor is to collect information on different aspects of the integration of ICT into education from a schools', teachers' and students' point of view. The benefits as well as the limitations of using this data are discussed in the next section.

5. Discussion of the results

Despite the large amount of research articles on gender differences and computer attitude, it is not yet very clear which non-school related factors and which school-related factors are relevant for explaining gender differences in computer attitude. There are four reasons which may explain this:

1. There is (still) limited empirical support available for the assumption that schools and teachers could influence student attitudes toward ICT.
2. Many research results are over-generalised, because often a convenient sample has been used (Meelissen, 2005).
3. A large number of different computer attitude (sub)scales are used and a theoretical foundation for these scales is often not clear (e.g. Kay, 1993).
4. In most studies, no distinction in ICT applications and uses of ICT is made, which makes it unclear what a student is thinking when he or she answers questions about 'the computer' (e.g. Eck, 2002).

For this study, the first two limitations do not apply. The choice for secondary analyses on the ICT-monitor data, as well as the choice for a conceptual model based on the structure of concentric circles, has made it possible to systematically search for empirical evidence for the assumed relationship (in the literature) between school related factors and the attitude of students toward ICT, in conjunction with non-school related factors. Using the ICT-monitor data for secondary analyses is also important for the desired generalisation of the results. As stated earlier, the results of this study can be regarded as representative of the research population (Dutch grade 5 students). Although the ICT-monitor collected data till 2001, these analyses were carried out on data from 1999. The instruments used in that year included the most relevant factors for answering the present research questions. Analyses on later data as well as earlier data, on the dependent variable and several other potentially influencing factors, revealed no important changes in time (Brummelhuis & Drent, 2000; van Kessel, van der Neut, Uerz, & Vermeulen, 2004). In 1999, computers were already intensively used for educational purposes in Dutch primary schools and used for a variety of learning goals. Research from 2004 indicates that although internet is more often used for educational purposes compared to 1999, other aspects of ICT-use (intensity of and variation in ICT-use, educational ICT-policy or attitudes of teachers toward ICT) has not changed considerably in primary education since 1999.

However, the third and fourth limitation of research on gender differences in computer attitude also apply for the current study. In the ICT-monitor, computer attitude only refers to the affective (pleasure in using computers) and cognitive (perceived relevance of computers) component. Research shows that gender differences in attitude are more explicit with regard to anxiety toward their computer use and self-confidence in computer use (the conative component, e.g. Charlton, 1999). Furthermore, in the ICT-monitor, only one of the 11 items is a negatively formulated statement about computers. Whitley (1997) emphasises that it is important to balance negative and positive statements because attitudes toward computers have a tendency to differentiate less if most items are formulated positively.

As in most studies on gender and computer attitudes, the ICT-monitor does not provide in-depth information about attitudes toward certain ICT applications or uses of ICT (Eck & Volman, 1999). However, a distinction in ICT-applications for the student factors 'variety out-of-school ICT use' and 'self-efficacy' is available in the data. The differences between ICT-applications regarding these student factors, emphasise that such a distinction is relevant for the computer attitude scale as well. Furthermore, the operationalization of ICT in the ICT-monitor, was limited to the use of computers, e-mail and internet. Other aspects of ICT, like mobile phones, were not included, because the project was mainly directed to the evaluation of educational uses of ICT.

The attitude toward ICT may also be influenced by the subject for which ICT is being used at school. Attitudes toward computers may be related to the attitude toward mathematics (Shashaani, 1995; Vale & Leder, 2004). Because in the Netherlands primary school girls have less positive attitudes toward mathematics than boys, the use of ICT during mathematics lessons may reinforce gender differences in attitudes toward both mathematics and ICT (Meelissen & Doornekamp, 2004).

Using the ICT-monitor data has limited this study in terms of the availability and validity of potentially relevant factors (including the dependent variable computer attitude). Examples of other 'missing' information in ICT-monitor are students' social economic background; computer attitude of parents and teachers, and students' computer activities in the classroom. However, not all limitations of this study can be attributed to the use of ICT-monitor data. In general, written questionnaires used for large-scale surveys have their limitations with regard to the kind of information that can be collected. Observation of lessons can provide more in-depth information about how boys, girls, and teachers respond to ICT use in an educational setting. At the same time, observation studies have their limitations too (Fraser, 1989). Observations are often limited to a small number of lessons, while written questionnaires collect data on experiences of students and teachers from many lessons. Furthermore, student perceptions of what is happening in class are likely to be more important for their attitudes than the actual observed situation.

Therefore, for future research on gender and ICT, a combination of both quantitative research (based on a representative sample) and case studies (selection of cases based on the quantitative data) seem a more appropriate research design. Case studies not only provide more insight into the relationship between gender and ICT, but can also be used as input for the further development of survey instruments and operationalisation of potentially influencing factors.

In this study, teachers's computer experience has a small positive effect on the computer attitude of girls, if the teacher is female. The percentage of female teachers in Dutch primary education is increasing rapidly (Driessen & Doesborgh, 2004), and future teachers will have more experience with ICT compared to the teachers participating in the ICT-monitor of 1999. Both developments may lead to the assumption that girls' contacts with positive role models at school will increase. However, in order to identify themselves with a teacher, it is important that students are inspired by a teacher who is a confident ICT-user. This study has also shown that female teachers are substantially less confident with ICT-use than male teachers, despite the absence of differences in ICT-use in the classroom. This means that teacher trainers should not only make their students aware of gender differences in computer attitudes and computer use of primary school children, but also pay attention to gender differences in self-confidence in ICT use of future teachers.

Finally, policymakers have often described gender differences in computer attitudes in terms of girls and women 'falling behind in today's information society'. This study and other studies show that both boys and girls are positive about computers in general and about computer use at school. As boys tend to overestimate and girls tend to underestimate when computer competency is concerned (Comber et al., 1997; Volman, 1994), the actual differences between the sexes in use and self-efficacy may be smaller than the gender differences in this study. More importantly, gender differences in attitudes, out-of-school computer use, and self-efficacy in computers can only be described in terms of 'falling behind', if use and attitudes of boys are regarded as 'the norm'. Instead of treating gender differences in computing as a 'falling behind' problem, it seems more important that schools and teachers are aware of these differences and try to prevent that these differences lead to (extra) barriers for girls when ICT is used for learning activities, especially—as this study revealed—in a more student oriented learning environment.

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