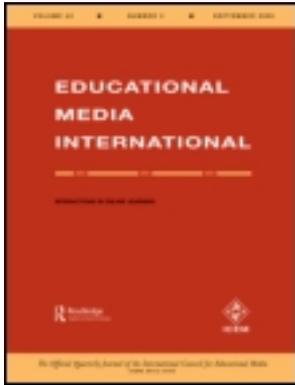


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Factors affecting teachers' student-centered classroom computer use

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The present study aims at investigating which factors are relevant to induce teachers' student-centered classroom computer use. Survey data were collected from 361 teachers at comprehensive schools. Based on a systemic view of technology use in schools, different individual teacher characteristics and school contextual factors were examined. Results from a four-step hierarchical regression reveal that student-centered classroom computer use could be significantly predicted by certain contextual factors: the type of school (secondary modern and high school), the existence of an ICT school policy plan, as well as by the individual teacher characteristics of belief in constructivist pedagogy and their frequency of classroom computer use. The final regression model accounted for approximately 31% of the variance in the outcome measure for these factors.

Keywords: constructivist pedagogical beliefs; individual teacher characteristics; regression analysis; school contextual factors; student-centered classroom computer use

Introduction

Recent reports suggest that the use of computers in schools has spread in the OECD countries, even though there are some differences between the frontrunner countries and those at the bottom of the league (Organisation for Economic Co-operation and Development [OECD], 2006). However, the intention to transform teaching and learning, thus achieving educational reform by classroom computer use, has so far been insufficiently applied (Cuban, 2001; Levin & Wadmany, 2008). Most teachers prefer a traditional method of classroom computer use, asking their students to complete tutorials, practice skills, and learn isolated facts (Niederhauser & Stoddart, 2001; Smeets, 2005; Tondeur, van Braak, & Valcke, 2007). Their teaching practices are based on a teacher-centred transmission model of teaching which assumes that knowledge is transmitted from the teacher to the learner, and that the learner acquires knowledge by some process of absorption (Biggs, 2001; Trigwell, Prosser, & Waterhouse, 1999).

Proponents of educational reform propose that computers should be used in connection with a student-centered pedagogy and should support active, self-directed, and exploratory learning. A variety of instructional practices should engage students in activities that support knowledge construction through media use, but which are

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not designed to control learning (Hokanson & Hooper, 2000). Rather, students should be challenged to learn by constructing meaning from a subject domain through exploration of ideas and problems. Computer-based social settings and authentic, project-based work are considered suitable for achieving these constructivist educational intentions. The present study is conducted in the context of this constructivist approach. The study focuses on computer-based student-centered classroom settings that induce active and self-directed learning. They range from students' computer-based presentation of independently worked out materials, to net-based collaborative learning, to computer supported project-based group work (Kozma, 2003a; Scardamalia & Bereiter, 1994). This study investigates which factors are decisive for teachers' student-centered classroom computer use. The study is based on an online survey of 361 teachers of German comprehensive schools who had sufficient levels of computer competency and had experience using computers in education.

Theoretical framework

Scope of the study

A lot of studies exist investigating what determines the educational use of computers in schools. Various factors have been found which influence classroom computer use: e.g., ICT infrastructure, ICT support, leadership and ICT school policy, computer experience of teachers, gender, teaching beliefs, and computer attitudes (see studies stating comprehensive sets of variables, e.g., Mueller, Wood, Willoughby, Ross, & Specht, 2008; O'Dwyer, Russel, & Bebell, 2004; Tondeur, Valcke, & van Braak, 2008). Even with all these studies, up to now very little empirical research has been conducted to investigate factors influencing a specific type of educational computer use, i.e., student-centered classroom computer use (Levin & Wadmany, 2008; O'Dwyer et al., 2004).

The present study distinguishes several factors that were assumed to influence student-centered classroom computer use. Some of these factors were chosen because there is research evidence suggesting them as relevant predictors. Still other factors were considered relevant and were included because they have been shown to be significant in general studies on classroom computer use. It was assumed from general classroom studies that technology use in schools is not a singular concept but has to be regarded as being influenced by a multitude of potential factors (O'Dwyer et al., 2004). The present study is oriented towards Tondeur, Valcke, and van Braak (2008), who distinguished two types of factors in their study on educational computer use in schools: individual teacher characteristics, and school contextual factors.

Individual teacher characteristics

Previous research has documented the influence of teachers' pedagogical beliefs on classroom practices (e.g., Kane, Sandretto, & Heath, 2002; Pajares, 1992). Accordingly, it is assumed that personal beliefs influence teachers' classroom computer use. However, only a few studies have examined this relationship (Ertmer, 2005). Niederhauser and Stoddart (2001) found that teachers who were more accepting of constructivist principles were more likely to use instructional software that was based on a student-centered conception of teaching and learning. Examples of such software are open-ended applications that enable students to construct a more

complex understanding of the learning material (for similar results see Tondeur, Hermans, van Braak, & Valcke, 2008). However, some studies found evidence for inconsistencies between teachers' beliefs and their classroom practices (Ertmer, Gopalakrishnan, & Ross, 2001; Fang, 1996; Kane et al., 2002). For example, Ertmer et al. (2001) found that teachers' beliefs about classroom technology did not always match their classroom practice. Teachers explained these inconsistencies by referring to contextual constraints, such as curricular requirements or social pressure exerted by parents, or peers. Ertmer (2005), in a review, drew the conclusion that the potential influence of still other individual and school contextual factors should be considered when examining the relationship between teachers' beliefs and educational practices.

Another variable incorporated in the present study is gender. Though an influence of gender on constructivist classroom computer use has not been proven until now, gender turned out generally to affect classroom computer use. That is to say, research revealed that male teachers had significantly higher levels of educational computer use than female teachers (Tondeur, van Keer, van Braak, & Valcke, 2008; Van Braak, Tondeur, & Valcke, 2004). Recently, some studies did not find gender differences and concluded that the gender gap is gradually dissipating (Gunn, McSporrán, Macleod, & French, 2003; Shapka & Ferrari, 2003). However, as the majority of previous research findings shows a clear tendency towards gender differences, gender was considered as a potential factor in the present study.

Frequency of classroom computer use appears, based on empirical evidence, to be another relevant variable. In their studies Hermans, Tondeur, van Braak, and Valcke (2008) as well as Tondeur, Hermans et al. (2008) showed a positive relation between constructivist beliefs and the frequency of classroom use of computers (for similar results see Becker & Ravitz, 2001; O'Dwyer et al., 2004).

Perceived usefulness of computers is a widely used variable in studies of technology use in a working environment (McGill, Klobas, & Renzi, 2011; Venkatesh & Davis, 2000). It has gained improved significance in studies of computer use in the educational domain as well (e.g., Friedrich & Hron, 2010; Lee, Cheung, & Chen, 2005; Yi & Hwang, 2003). Perceived usefulness is defined as the extent to which a person believes that using the computer system would be useful for achieving his or her specific goals (Davis, 1989). This concept originates from the technology acceptance model (TAM; Davis, 1989) that has proven to be a powerful model for predicting information technology usage (Venkatesh, Morris, & Davis, 2003). This concept has been proven valid also in educational studies (e.g., Chang & Tung, 2008; Lee et al., 2005; Ong & Lai, 2006). We therefore considered this concept relevant for the present investigation and hypothesized an influence of perceived usefulness on student-centered classroom computer use.

School contextual factors

Type of school was considered a relevant school contextual factor for the present study. In the German school system, there are four different types of comprehensive schools: primary school (Grundschule), lower secondary school (Hauptschule), secondary modern school (Realschule), and high school (Gymnasium). With respect to the relation of type of German school and student-centered classroom computer use there is no clear research evidence (Herzig & Grafe, 2007). However, Niederhauser and Stoddart (2001) provided an indication of how type of school and use of

computers might be related. They found that the majority of teachers in their sample used interactive, exploratory software in the early grades – indicating student-centered practices – but shifted towards a more restricted or skill-based software in the higher grades. In view of the inconclusive state of research, we were interested to incorporate this issue of type of school into our study.

ICT infrastructure in a school was considered another relevant contextual variable. Research shows in general that adequate technical resources are an important prerequisite for teachers integrating computers into the classroom (Bradley & Russel, 1997; Smeets, 2005). When constructivist-oriented teachers have a sufficient number of computers at their disposal at school and have achieved a reasonable level of experience and skill in using computers themselves, a majority of such teachers will guide their students in the active and regular use of computers during their class period (Becker & Ravitz, 2001).

ICT school policy plan seems to be another relevant variable. Research shows that the existence of an ICT school policy plan in general has a significant effect on class use of ICT (Tondeur, van Keer et al., 2008). With respect specifically to student-centered classroom computer use, Kozma (2003b) points out that teachers working in schools that are engaged in ICT planning are more likely to apply computers in an innovative way.

Collegial support was taken into account as a further potential predictor of student-related classroom computer use (Griffin & Rankine, 2010; Zhao & Frank, 2003). Chiero (1997) points out that increased communication as a general manifestation of collegiality would be a valuable resource for teachers who wish to use ICT effectively in their classes. The existence of a social network of computer-using teachers at the same school seems to be an important factor in sustaining their media-based pedagogy (Becker, 1994; Chiero, 1997). In view of these research results we were interested to learn whether collegial support would be relevant to student-centered computer-based instruction.

Research question

In investigating which factors are significant for teachers' student-centered classroom computer use, the variables noted above are considered as independent variables. The student-centered method of computer usage was operationalised as dependent variable, identified by teachers' statements about applying computers in contexts of social learning and project-based work. The statements were extracted from research literature on constructivist instructional practices (Kozma, 2003a; Scardamalia & Bereiter, 1994). They ranged from students' computer-based classroom presentations of independently worked out materials, to collaborative learning of locally distributed students, further to computer supported project-based group work. The hypothesis derived from the discussed research findings was that the independent variables would be positive predictors of using computers in a student-centered way.

Method

Participants

A total of 361 teachers of German comprehensive schools participated in the survey. These teachers were visitors of the web portal *Lehrer-Online*, the most prominent German web portal for use of media in the classroom. They responded

to an invitation to participate in an online survey that was placed on the homepage of Lehrer-Online. One hundred and seventy-one (47%) teachers were female and 190 (53%) teachers were male. The mean age was 45 years ($SD = 9,4$ years, $min. = 26$, $max. = 64$). 47 (13 %) teachers taught in primary schools (Grundschule), 32 (9%) teachers taught in lower secondary schools (Hauptschule), 46 (13%) teachers taught in secondary modern schools (Realschule), 212 (59%) teachers taught in high schools (Gymnasium), and 24 (7%) teachers taught in two or more of these types of school.

Due to the method of online survey the data of this study are not based on a random sample. It has to be presumed that the teachers actively using the Lehrer-Online web site had sufficient levels of computer competency and had experience using computers in the classroom. With respect to the aims of this study, this seems to be acceptable.

Procedures

A link to the survey was placed on the homepage of Lehrer-Online at the beginning of February 2007; it stayed there the whole month. Advertising for the survey was done on Lehrer-Online and in the newsletter of the portal. As an incentive, participants of the survey could be entered into a raffle to win a gift coupon for a book.

Instrumentation

Several items or scales were used to measure the variables in the study (see Table 1 for means and standard deviations of scores and number of respondents). The score of a respondent on a scale was computed as the raw score divided by the number of items in the respective scale. Gender was measured by a single item (male = 0; female = 1).

Constructivist pedagogical beliefs with respect to computers were measured by five items from the study of Niederhauser and Stoddart (2001). Each item was a statement of a constructivist instructional goal. Participants rated the effectiveness of computer-based instruction for each instructional goal on a response scale ranging from 1 (low) to 5 (high) (theoretical minimum/maximum: 1/5) ($\alpha = 0.78$). Sample items include: helping students to construct their own representations of concepts; developing higher-order thinking skills.

Perceived usefulness was measured with a scale of four Likert-type items ($\alpha = 0.77$), based on the framework of Davis (1989), with response scales ranging from "1" (does apply to a minor degree) to "5" (does apply to a high degree) (theoretical minimum/maximum: 1/5). Sample items include: the computer enhances my productivity; the computer makes my working organization easy.

Frequency of classroom computer use was measured by a forced choice question from the PISA study (OECD, 2006) consisting of five response alternatives: "5" (= almost every day), "4" (= a few times each week), "3" (= between once a week and once a month), "2" (= less than once a month), "1" (= never) (theoretical minimum/maximum: 1/5).

Type of school was recorded by a multiple response question, where participants could choose one or more of the following options: primary school, lower secondary school, secondary modern school, high school. To include type of school in the regression analysis (see below) the five response categories (the above denoted four

types of school plus responses indicating that teachers taught at more than one type of school) were recoded into four dummy variables (primary school: 1/0, lower secondary school: 1/0, secondary modern school: 1/0, high school: 1/0).

ICT infrastructure was assessed by a five-item scale ($\alpha = 0.67$). Each item had a no (= 0)/yes (= 1) response format (theoretical minimum/maximum: 0/1). Sample items include: Access to the Internet is sufficiently fast; at my school there is a sufficient number of computers. ICT school policy plan was measured by the following item: An ICT policy plan exists at my school (no = 0, yes = 1) (theoretical minimum/maximum: 0/1).

Collegial support was measured by a two-item scale ($\alpha = 0.68$). Each item had a no (= 0)/yes (= 1) response format (theoretical minimum/maximum: 0/1). Sample items include: Colleagues at my school are ready to support me if I have an issue with pedagogically integrating computers.

Student-centred classroom computer use was measured by a multiple response question indicating a broad range of student-centered methods when using computers in the classroom. The participants could choose one or more of nine response categories that were statements about student-centered classroom computer use ($\alpha = 0.68$). The question read: For which of the following classroom activities do you use the computer? The response categories were extracted from research literature on constructivist instructional practices (Scardamalia & Bereiter, 1994). Sample items include: Pupils use the computer to present projects they worked out independently; I let pupils work with computers in the context of longer-lasting project work. External validity of the scales seemed assured. Some scales were extracted from well-grounded studies (see above). The other scales were reviewed by three educational psychologists who agreed upon their validity. The questionnaire data was coded by the research team. Data analysis was done by using the Statistical Package for the Social Sciences (SPSS).

Results

Table 1 presents means and standard deviations for the variables used, Table 2 the results of the correlation analysis. The mean (4.75; SD = 2.13) of the scale concerning student-centered classroom computer use indicates that altogether teachers implemented a medium range of the various computer-based learning scenarios included in the inquiry.

A four-step hierarchical regression was conducted to explore further the relationships between the independent variables and teachers' student-centered classroom computer use. In step 1 and step 2 the independent variables concerning the school contextual factors were added to the model: in step 1 the four types of school as dummy variables (primary school, secondary modern school, lower secondary school, and high school), in step 2 additionally ICT infrastructure, collegial support, and ICT school policy plan. In step 3 and step 4 the variables concerning the individual teacher characteristics were added: in step 3 gender as a dummy variable and frequency of classroom computer use, in step 4 perceived usefulness and constructivist computer-related pedagogical beliefs. The order of the steps reflects the intention to measure separately the influence of the school contextual factors (steps 1 and 2) and the influence of the individual teacher characteristics (steps 3 and 4).

Table 3 provides a summary of the hierarchical regression analysis. As indicated, after incorporating the variables concerning the type of school (step 1)

Table 1. Descriptive statistics and Cronbach's alphas for the measured variables.

Variable	n	M	SD	α
1. Student-centered classroom computer use	361	4.75	2.13	.68
2. Computer-related constructivist beliefs	355	2.80	.63	.78
3. Perceived usefulness	361	3.91	.71	.77
4. Frequency of classroom computer use	359	2.45	.95	–
5. Gender	361	.47	.50	–
6. ICT school policy plan	356	.53	.50	–
7. Collegial support	361	.61	.40	.68
8. ICT infrastructure	361	.66	.31	.67
9. High school (10-13 grade)	361	.59	.49	–
10. Secondary modern school (5-10 grade)	361	.13	.33	–
11. Lower secondary school (5-9 grade)	361	.09	.28	–
12. Primary school (1-4 grade)	361	.13	.34	–

into the regression, only the variable primary school explains a small but significant amount of the variance of the criterion ($\beta = -.18, p = .030$). In the second step, where the remaining school contextual variables are taken into account, in addition to primary school ($\beta = -.19, p = .023$), ICT infrastructure ($\beta = .16, p = .004$) and ICT school policy plan ($\beta = .15, p = .004$) turn out to be significant. In the third step when the individual teacher variables (gender, frequency of classroom computer use) were introduced secondary modern school ($\beta = .16, p = .034$), high school ($\beta = .23, p = .014$), ICT school policy plan ($\beta = .12, p = .017$), and frequency of classroom computer use ($\beta = .40, p = .000$) turn out to be significant.

Finally, after introducing perceived usefulness and constructivist computer-related beliefs in the fourth step, five variables proved to be of significant influence: secondary modern school ($\beta = .17, p = .018$), high school ($\beta = .25, p = .007$), ICT school policy plan ($\beta = .09, p = .050$), frequency of classroom computer use ($\beta = .38, p = .000$), and constructivist computer-related beliefs ($\beta = .13, p = .007$).

With respect to the school contextual factors the results reveal that throughout the regression steps 2, 3 and 4, ICT school policy plan proved to have influence on student-centered classroom computer use. The same applies to secondary modern school and high school throughout step 3 and 4. Concerning individual teacher characteristics, the results of the final regression model (step 4) prove frequency of classroom computer use and constructivist computer-related beliefs to be predictor variables within the set of predictors selected for this study. All in all, the predictor variables explain approximately 31% of the variance in teachers' student-centered classroom computer use, which means a medium effect size (Cohen & Cohen, 1983). To be sure that these findings did not result from the ordering of the steps of the regression, a further regression was computed with individual teacher characteristics in the first and second step and the school context variables in the third and fourth step. However, there were no different β -values for the predictors in this arrangement.

Discussion and conclusion

The results of this study did not confirm the assumption that all of the hypothesized variables would be significant predictors. Concerning school contextual factors, two types of school, secondary modern school, and high school, proved to be significant

Table 2. Pearson correlations for the measured variables.

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Student-centered classroom computer use	—	.201**	.107*	.393**	-.218**	.187**	.047	.210**	.138**	.081	.010	-.259**
2. Computer-related constructivist beliefs		—	.160**	.248**	-.025	.137**	.080	.038	-.001	-.016	.004	-.076
3. Perceived usefulness			—	.154**	.129*	.113*	-.016	.018	-.066	.030	.050	.042
4. Frequency of classroom computer use				—	-.166**	.108*	-.155**	.147**	.211**	.070	.078	.090
5. Gender					—	.028	.048	-.020	-.182**	.097	-.080	.261**
6. ICT school policy plan						—	.195**	.249**	.008	-.003	-.036	.014
7. Collegial support							—	.234**	.263**	-.023	-.112*	-.243**
8. ICT infrastructure								—	.131*	.016	-.065	-.115*
9. High school (10-13 grade)									—	-.456**	-.372**	-.461**
10. Secondary modern school (5-10 grade)										—	-.119*	-.148**
11. Lower secondary school (5-9 grade)											—	-.121*
12. Primary school (1-4 grade)												—

Notes. * $p \leq .05$, ** $p \leq .01$.

Table 3. Summary of hierarchical regression analysis for variables predicting student-centered classroom computer use (N = 361).

Variable	b	SE _b	β
Step 1			
Primary school	-1.14	.53	-.18*
Lower secondary school	.32	.56	.04
Secondary modern school	.80	.53	.13
High school	.54	.45	.12
Step 2			
Primary school	-1.18	.52	-.19*
Lower secondary school	.36	.55	.05
Secondary modern school	.76	.51	.12
High school	.54	.44	.13
ICT infrastructure	1.07	.37	.16**
Collegial support	-.47	.29	-.09
ICT school policy plan	.65	.23	.15**
Step 3			
Primary school	-.79	.47	-.13
Lower secondary school	.51	.50	.07
Secondary modern school	.99	.47	.16*
High school	1.00	.41	.23*
ICT infrastructure	.55	.34	.08
Collegial support	-.01	.27	.00
ICT school policy plan	.49	.20	.12*
Gender	-.34	.21	-.08
Frequency of classroom computer use	.90	.11	.40**
Step 4			
Primary school	-.64	.47	-.10
Lower secondary school	.57	.50	.08
Secondary modern school	1.10	.47	.17*
High school	1.09	.40	.25**
ICT infrastructure	.58	.33	.09
Collegial support	-.01	.27	-.01
ICT school policy plan	.39	.20	.09*
Gender	-.39	.21	-.09
Frequency of classroom computer use	.85	.11	.38**
Perceived usefulness	.17	.13	.06
Constructivist pedagogical beliefs	.43	.16	.13**

Notes. R² = .08 for Step 1; ΔR² = .06 for Step 2; ΔR² = .16 for Step 3; ΔR² = .02 for Step 4 (ps ≤ .01). Gender and type of school were dummy coded. b = unstandardised regression coefficient; SE_b = standard error of b; β = standardised regression coefficient.

*p ≤ .05; **p ≤ .01.

predictors of teachers' student-centered classroom computer use. Moreover, ICT school policy plan also turned out to be a significant predictor. The remaining school contextual factors, i.e., the school types primary school and lower secondary school, as well as ICT infrastructure and collegial support did not prove to be significant predictors. Concerning individual teacher characteristics, constructivist pedagogical beliefs and frequency of classroom computer use significantly predicted student-centered classroom computer use. In contrast, gender and perceived usefulness of computers did not prove to be significant predictors.

Regarding the influence of secondary modern school and high school, we have to assume that the way student-centered classroom computer use was operationalised had an effect. The participating teachers were asked whether they use computer-based

learning scenarios, like project work, self-regulated learning or students' media-based presentation of independently worked out contents. These computer-based scenarios induce high-order learning activities that demand active and self-regulated learning. It can be assumed that such activities are more customary in the higher grades than in primary schools and lower secondary schools. In fact, this issue raises the general question whether students in lower grades would be able to meet the requirements of computer-based instructional formats that presume active and self-regulated learning (cf. Jenkins, 2000). ICT school policy plan, turning out to be a significant predictor, suggests that incorporating computer use into curricular planning has positive effects on innovative classroom computer use (see also Kozma, 2003b; Tondeur et al., 2008). Contrary to our expectation collegial support proved to have no influence on student-centered classroom computer use. The reason behind this finding might be that the teachers of the sample have had a lot of experience in classroom computer use and did not think they needed collegial support. ICT infrastructure also did not turn out to be a relevant factor. It can be assumed that the schools in our survey are sufficiently equipped with computers and that this issue was of no importance for the participating teachers.

With respect to individual teacher characteristics, constructivist pedagogical beliefs and frequency of classroom computer use proved to be significant predictors for student-centered classroom computer use. This result corresponds to existing research findings (Ertmer, 2005; Niederhauser & Stoddart, 2001; Tondeur, Hermans et al., 2008). Moreover, frequency of classroom computer use proved to have a significant influence on using student-centered classroom technology (cf. Becker & Ravitz, 2001; Hermans et al., 2008; O'Dwyer et al., 2004). This result appears to be a manifestation of a complex relationship that is associated with the frequency of classroom computer use and teachers' constructivist beliefs: Research of Becker and Riel (1999) showed that teachers with more distinct constructivist beliefs and increased classroom computer use showed higher confidence in using the technology and more positive beliefs about the efficacy of computer technology.

In contrast, gender and perceived usefulness of computers did not prove to be significant predictors. Concerning gender, this result means that in the investigated sample there was no gender specific difference in student-centered classroom computer use. The missing influence of perceived usefulness can be attributed to the high degree of experience the participants had with computers. Their judgements of perceived usefulness show a high mean value (see Table 1), suggesting a ceiling effect that could account for the missing influence of perceived usefulness. The present study provides a selected sample of teachers with sufficient experience in educational computer use, at schools where the participating teachers approved of an ICT infrastructure as sufficient. For a sample of teachers with less computer-related experience and schools with poor ICT equipment, modified result would be expected. In such a case the variables collegial support, ICT infrastructure and perceived usefulness which did not prove to be of influence in this study could turn out to have an effect on student-centered classroom computer use.

The investigation here was restricted to a limited number of factors that were assumed to affect student-centered classroom computer use. Moreover, no interaction effects of these factors were taken into account. Other factors could be of relevance, e.g., besides the individual and school contextual factors examined here, curricular variables, especially different school subjects, are likely to play a role.

Also, complex interrelations among influencing factors could be possible and would be relevant to be investigated. Altogether, this study reveals that student-centered classroom computer use depends on a complex context of various factors. Further studies are necessary to explain the complex interrelation between student-centered classroom computer use and possible influencing factors. Such studies should be based on a systemic approach (O'Dwyer et al., 2004). Moreover, besides studies with quantitative methods additional qualitative studies would also be a desirable direction for the research into student-centered computer use in the classroom (Levin & Wadmany, 2008).

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