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Published in:
Education and Information Technologies

DOI (link to publication from Publisher):
[10.1007/s10639-017-9629-7](https://doi.org/10.1007/s10639-017-9629-7)

Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

[Link to publication from Aalborg University](#)

Citation for published version (APA):

Scholkmann, A. (2017). “What I learn is what I like.”: How do students in ICT-supported problem-based learning rate the quality of the learning experience, and how does it relate to the acquisition of competences? *Education and Information Technologies*, 22(6), 2857–2870. <https://doi.org/10.1007/s10639-017-9629-7>

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“What I learn is what I like.” How do students in ICT-supported problem-based learning rate the quality of the learning experience, and how does it relate to the acquisition of competences?

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Received: 26 March 2017 / Accepted: 12 July 2017 / Published online: 20 July 2017
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Abstract Although advocated in theory, research findings on the benefits of ICT integration into inquiry-based learning arrangements such as problem-based learning (PBL) are still ambiguous. One explanation might be that until now students’ subjective views on learning in ICT-integrated, inquiry-based arrangements have not been considered extensively. The aim of the present study was to shed light on how students’ attitude towards various face-to-face and ICT-supported learning opportunities within a PBL course related to the learning outcomes, namely participants’ competence acquisition. To this end, a sample of $n = 46$ pre-service teacher students in a blended PBL course on pedagogical diagnostics for business and vocational education answered an online questionnaire. The questions explored the quality of the learning experience in the face-to-face and ICT-supported elements, and the students’ perceived competence acquisition. Data was analyzed with multiple regression analysis. Subjective satisfaction with the learning experience predicted competence acquisition for both face-to-face and ICT-supported course elements, but only if they were interactive in nature. In conclusion, ICT integration in a PBL course is not necessarily a threat but a benefit; however, this is true only when it is used within active and engaging learning opportunities.

Keywords ICT integration · Inquiry-based learning · Problem-based learning · Competence acquisition · Quality of the learning experience

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1 Introduction

Inquiry-based learning arrangements, such as problem-based learning (PBL), are considered a powerful means to support the acquisition of subject-specific and generic competences (Education International: The European Students' Union 2010; Hmelo-Silver 2004; Savin-Baden et al. 2004). Inquiry-based learning essentially expects students to work on authentic cases or “problems” in groups and assisted by a tutor. Students analyze the cases and formulate individual research questions, which facilitate the building of an extensive knowledge base through research (cf. Loyens and Rikers 2011). Knowledge-transferring learning opportunities such as lectures and seminars are significantly reduced in terms of time (Loyens et al. 2012; Schmidt et al. 2009).

Beyond face-to-face and synchronous learning, inquiry-based arrangements are also increasingly leveraging the potential of ICT-supported asynchronous and distance learning opportunities (cf. e.g. Green et al. 2004; de Leng et al. 2006; Wagner et al. 2010; Woltering et al. 2009). In this context, learning management systems (LMSs) provide additional learning resources (e.g. lecture notes, literature, knowledge tests etc.) as well as structuring and facilitating of the learning process (e.g. through instructional design elements, cf. Hillen and Päiväranta 2012). More important, though, is the use of ICT-supported knowledge exchange and communication tools such as wikis and forum discussion spaces, which provide room for self-directed and collaborative engagement with the course subject (cf. Green et al. 2004; Hillen 2014).

Studies on the effectiveness of inquiry-based learning often suppose that students participating in such an arrangement enjoy greater learning success than those taught in traditional, lecture-based courses. Previous research has been strongly shaped by this assumption, with the studies comparing students from inquiry-based and lecture-based arrangements (e.g. Belland et al. 2010; Cohen-Schotanus et al. 2008; Dochy et al. 2003; Schmidt et al. 2009). These studies have shown that learners benefited from inquiry-based arrangements in several respects: Participants retrospectively reported a significantly higher acquisition of competences in problem solving, cooperation or team competence and communicative abilities (cf. e. g. Cohen-Schotanus et al. 2008; Schmidt et al. 2006). According to studies in teacher education, the participants were able to acquire systematic and personal competences to a significant extent (Scholkmann and Küng 2016; cf. also Brassler and Dettmers 2016).

Despite their valuable findings overall, there are two kinds of shortcoming in the studies cited. Firstly, they tend to attribute the acquisition of competences to participation in the learning arrangement as a whole and fail to consider the fact that inquiry-based learning arrangements may consist of different, face-to-face and ICT-supported learning opportunities such as lectures, casework, tutorial group meetings, individual studies, etc. Secondly, they do not take into account that learners have different instructional preferences; these have been shown to significantly influence individual participants' engagement with and benefit from participation in any instructional arrangement. Hence, the resulting (and divergent) effects found in previous studies tend to be imprecise and difficult to interpret.

The present study aimed to shed light on how the *perceived* quality of the learning experience in different learning opportunities of an ICT-supported PBL course affected the participants' acquisition of competences. The underlying research question was:

- How does the perceived quality of the learning experience in different face-to-face and ICT-supported learning opportunities of an inquiry-based learning arrangement influence the acquisition of competences?

2 Previous findings

2.1 Competence acquisition and the influence of different learning opportunities

As discussed, previous studies often only considered participation in an inquiry-based learning arrangement per se to be a predictor of competence acquisition (e. g. Cohen-Schotanus et al. 2008; Schmidt et al. 2009; Scholkmann and Küng 2016). The mere exposure to a specific inquiry-based instructional arrangement, however, should not influence the acquisition of competences decisively. After all, inquiry-based instructional arrangements usually consist of a package of different face-to-face and ICT-supported learning opportunities. Furthermore, competence in itself must be differentiated into sub-categories such as the competence to process factual knowledge (*knowledge processing competence*), to work systematically on a problem (*systematic competence*), to cooperate and communicate effectively (*communication competence and team competence*), and to improve intrinsic motivation and interest in a subject matter (*personal competence*, cf. Braun and Leidner 2009; Braun et al. 2011).

Regarding the benefits of learning under inquiry-based paradigms in general, there is a widespread assumption that they address an array of competences beyond mere knowledge acquisition (e. g. Hmelo-Silver 2004). A closer look at the different learning opportunities (face-to-face and ICT-supported) within an inquiry-based arrangement, however, reveals that these have different effects on the acquisition of different competence facets.

The acquisition of *knowledge-processing competence* seems to be fostered by authentic casework, which is considered the core of inquiry-based learning. Working with cases is supposed to motivate students intrinsically because of the format's authentic and situated nature and the possibility to form individual learning goals. This can lead to a greater interest in the subject and a more permanent occupation with the learning content beyond what is required in the classroom (Hmelo-Silver 2004). However, the assumption that casework fosters knowledge processing competence is challenged by a more traditional notion, which argues that students in lecture-dominated curricula show better academic achievements in standardized tests and achieve better grades in the final examinations (Baeten et al. 2013). Also based on the rather receptive focus of lectures, we can assume that this learning opportunity especially encourages factual and conceptual knowledge acquisition (cf. also Exley 2009, p. 4).

Regarding the acquisition of *systematic competences* in inquiry-based arrangements, previous results have shown that the casework learning opportunity is especially beneficial. The use of an integrated LMS has also been shown to have a positive influence on the acquisition of systematic competences. Participants in a teacher-training PBL course assessed their systematic competence as being higher after the course than their traditionally taught counterparts (Scholkmann and Küng 2016). Learners in a newly implemented online element accompanying an inquiry-based course also reported positive effects on their learning process skills thanks to LMS

tools such as e-mails, calendars, self-learning tasks and rapid-access intermediate exam results (Green et al. 2004). However, not all studies confirm that learners find ICT-supported learning arrangements helpful in acquiring systematic competences (Hillen and Päiväranta 2012).

It can be assumed that authentic casework in inquiry-based arrangements also strongly supports the development of *communication competence*, *team competence* and *personal competences*. This can be attributed largely to the collaborative efforts required in casework. Besides knowledge acquisition and systematic competence, collaboration fosters generic communication and team competences. The empirical findings, however, are inconsistent. For instance, learners reported that a structured approach in problem solving limited the free development of their communication competence (Scholkmann and Küng 2016). With regard to the development of personal competence, it has been assumed that casework leads to a greater interest in the topic because of its situated and activating character (Hmelo-Silver 2004). Individual studies showed that in some cases learners in problem-based learning arrangements actually changed their learning style from deep to strategic (e.g. Iputo 1999). Besides casework, it can be assumed that the use of ICT-supported communication tools also increases communication, team and personal competence acquisition because it intensifies the communication between course participants, enabling them to exchange ideas outside the classroom (e.g. Hillen 2014). Empirically, it was shown that learners experienced an improvement in their communicative competence through ICT-supported commenting tasks (Bower et al. 2011). Finally, ICT-supported communication tools have been assumed to foster team and personal competence since they allow learning to be experienced as a collaborative process. They also provide learners with the “ownership” of their learning process (cf. Hillen 2014: 133).

2.2 Perceived quality of the learning experience and resulting competence acquisition

Previous studies into competence acquisition often considered participation in an inquiry- or lecture-based learning arrangement to be a predictor per se of experience. The mere exposure to a specific instructional arrangement, however, does not seem to influence the acquisition of competences decisively. In fact, the acquisition of competences seems to be most influenced by attitudes towards the learning experience in different instructional arrangements (e.g. Doménech Betoret and Descals Tomás 2003; Hattie 2009). This makes sense from a socio-psychological perspective. The attitude towards a given object is known to predict the probability of certain behaviors individuals will show in order to obtain this object. This is particular true if the behavior is assessed as feasible and the goal achievable (e.g. Aijzen 2001). Transferred to instructional arrangements, reasonable learning behavior will only take place if the required learning activities seem to be executable and the intended learning goals appear achievable.

A good body of empirical research substantiates this claim. Firstly, several studies showed that learners differed in their attitudes towards and preferences for different learning opportunities with various instructional requirements (e.g. Cavanagh and Coffin 1994; Sadler-Smith and Riding 1999). Secondly, it was shown that individual beliefs and attitudes towards a learning opportunity influenced preferences for certain

tasks. A recent study showed that students with a deep approach to learning preferred tasks with a high proportion of self-controlled, knowledge-constructed and collaborative activities. In contrast, students with a surface approach preferred teacher-led and less autonomous tasks (Baeten et al. 2015). In a PBL context, learners who preferred open, problem-based arrangements were found to benefit more from these arrangements and appreciated the learning experience more (Papinczak 2009).

Thirdly, the attitude towards and perception of the task has been demonstrated to influence learning outcomes. Learners in a science course only showed significant improvement in representative thinking if they perceived the lessons as being beneficial for this competence (Nitz et al. 2014). Moreover, learners reached higher scores in a standardized test if their attitude towards the preparatory learning experience was positive (Sankaran et al. 2000). As a result, research into inquiry-based learning should examine attitude more closely as an influencing factor for competence acquisition.

2.3 Hypotheses

Evidence available so far suggests that in an inquiry-based arrangement such as PBL *knowledge processing competence* should be influenced by attitude towards lectures and casework, since both have been demonstrated to affect this competence before. Regarding the acquisition of *systematic competence*, previous results have shown that it can be influenced by the learner's attitude towards the experience of the learning opportunities casework and general LMS usage. It can be assumed that acquisition of *communication competence*, *team competence* and *personal competence* is mainly affected by the attitude towards the experience in the learning opportunities casework and use of ICT-supported communication tools. For the development of *personal competence*, it can be assumed that the attitude towards casework leads to deeper knowledge processing and a greater interest in the topic because of its situated and activating character. Furthermore, use of ICT-supported communication tools as learning opportunities can be assumed to intensify the communication between course participants by enabling the exchange of ideas outside the classroom. In conclusion, we formulate the following hypotheses:

- The acquisition of *knowledge processing competence* is predicted by high perceived quality of the learning experience in the lecture and when working with authentic cases (H1).
- The acquisition of *systematic competence* is predicted by a high perceived quality of the learning experience in casework and when using an LMS as an additional learning resource (H2).
- The acquisition of *communication competence* is predicted by a high perceived quality of the learning experience in casework and when using ICT-supported communication tools (H3).
- The acquisition of *team competence* is predicted by a high perceived quality of the learning experience in casework and when using ICT-supported communication tools (H4).
- The acquisition of *personal competence* is predicted by a high perceived quality of the learning experience in casework and when using ICT-supported communication tools (H5).

3 Method

3.1 Sample and study context

The study was conducted in a course on pedagogical diagnostics in the second semester of a master's program for pre-service vocational education teachers. The learning objective of the course was to provide students with knowledge and skills regarding diagnostic theory, methods and fields of application. The course consisted of a weekly alternating content-focused lecture and authentic problem solving tasks. The latter were implemented in small groups using a traditional PBL-approach (working on problems by means of a defined process). A total of 6 PBL-cases had to be solved within the 14-week course. In a variation on the traditional PBL approach, however, the students had to form small groups and organize the process themselves without a tutor.

The course was integrated within an ICT-based LMS based on Open Learning and Teaching (OLAT, cf. <http://www.frentix.com/>). The LMS provided additional learning materials and organizational resources (lecture notes, video recordings of the individual lectures, additional documents and literature, course schedule). It was also used as a learning opportunity, focusing on exchange and discussion between participants at content level. For this purpose, online forums were activated for every course date so that the students could share and comment on their thoughts, questions and content reflections.

As a proof of performance, participants submitted written compositions on 2 of 6 case studies, including documentation on the work process and individual research results from self-generated questions regarding the case. Performance was evaluated based on a set of criteria, whereby at least 6 of 7 categories had to be rated "sufficient" to pass the course. In addition, participants had to post at least 3 content-related comments in forums. The posted content was checked, but not qualitatively assessed. $N = 46$ students participated in the study.

3.2 Instruments

3.2.1 Evaluation of the perceived quality of the learning experience

The quality of the learning experiences in the different learning opportunities was evaluated by considering three components in the different learning opportunities provided in the course. These were satisfaction (affective component), perceived difficulties (cognitive component), and overall assessment (behavioral component) of the learner. The following learning opportunities were evaluated (variable labels in brackets): working on PBL cases (*Casework*), participation in the lecture (*Lecture*), usage of the learning management system as an additional learning resource (*LMS*), and ICT-supported discussions in forums (*Forum discussions*). Exemplary items include: "I have fun discussing in the forums" (*Forum discussions*, affective component), "The case studies had the right degree of difficulty" (*Casework*, cognitive component), or "It was easy for me to work with OLAT as additional learning resource right from the beginning" (*LMS*, behavioral component). The items were averaged on the respective scale. This procedure was based on a previous reliability analysis, which showed good coefficients for all four

variables (.81 < Cronbach's Alpha < .88). A complete overview of all items used and the corresponding scale values can be found in Table 1.

3.2.2 Evaluation of self-assessed competence acquisition

The self-assessed competence acquisition was evaluated with five of the six HESaCOM scales (Braun and Leidner 2009). HESaCOM is a questionnaire that evaluates competences by means of personal statements according to the construct of professional action competence. The following scales were used: *Knowledge processing*, *systematic competence*, *communication competence*, *cooperation competence* and *personal competence*. In the present study, as in the original design of the procedure, every statement could be rated from 1 = I don't agree to 5 = I agree. A reliability check with the present evaluation data showed satisfactory results for the scales used. They ranged between $\alpha = .94$ (scale *Communication competence*) and $\alpha = .81$ (scale *Knowledge processing*).

Table 1 Quality of the learning experience; survey items and statistics

	<i>M</i>	<i>SD</i>	<i>N</i>	Cronbach's Alpha
Casework				.81
The cases were written understandably.	3.93	1.00	46	
The cases were appropriate in their difficulty.	3.89	.88	46	
Working on the cases was fun to me.	3.46	1.10	46	
Lecture				.85
The content of the lecture was prepared understandably.	4.52	.51	46	
I was able to follow the content of the lecture.	4.46	.62	46	
The content of the lecture was appropriate in its difficulty.	4.46	.62	46	
LMS				.88
It was easy for me to work with OLAT as additional learning resource right from the beginning.	3.91	1.28	45	
Using OLAT was fun to me.	3.22	1.31	45	
Using OLAT made it easier for me to attend or follow the course (for instance through watching the lecture videos).	3.82	1.25	45	
The technical complexity of OLAT was a high hurdle for me (R).	3.93	1.23	45	
I consider learning with a learning management system like OLAT to be a useful addition to traditional face-to-face learning opportunities.	3.91	1.28	45	
Forum discussions				.87
Posting contributions in the forums was fun to me.	2.78	1.30	45	
The tone of the discussions in the forums was appropriate.	3.60	1.16	45	
Reading the other participants' comments in the forums was beneficial for the development of my own understanding.	3.31	1.28	45	
Reading the professor's comments in the forums was beneficial for the development of my own understanding.	4.07	.99	45	
Through the forum discussions I have gained a better understanding of the topics covered in this course.	2.91	1.31	45	

3.2.3 Procedure

Data was collected in the first week of the summer holidays 2015 after completion of the course. The students were emailed a link to the online evaluation system EvaSys.

3.3 Data analysis

Regression analyses were carried out to verify all hypotheses. This was done for all five competence dimensions (*Knowledge acquisition, Systematic competence, Cooperation competence, Team competence and Personal competence*) as dependent variables and the assessment of the variables *Casework, Lecture, LMS and Forum discussions* as independent variables. Regression analyses were considered adequate because the competence dimensions were independent of each other. The assessments of the perceived quality of the learning experiences were included as predictors in the models, with all learning experiences added to all models on an exploratory basis. All analyses were carried out with SPSS 22.

4 Findings

Mean values showed that the quality of the learning experience was assessed positively in all four learning opportunities. Quality of the learning experience was rated best for the variable *Lecture* ($M = 4.48$, $SD = 0.51$) followed by *LMS* ($M = 3.77$, $SD = 1.03$), *Casework* ($M = 3.76$, $SD = 0.84$) and *Forum discussions* ($M = 3.34$, $SD = 3.34$).

With regard to the self-assessed competence acquisition, medium values were obtained for all scales, with *Team competence* reaching the highest value ($M = 4.43$, $SD = 0.98$), followed by *Knowledge processing* ($M = 3.41$, $SD = 0.62$), *Personal competence* ($M = 3.24$, $SD = 0.89$), *Systematic competence* ($M = 2.71$, $SD = 1.00$) and *Communication competence* ($M = 2.30$, $SD = 1.00$). (Individual missing values in the team competence scale occurred because a filter item was set.)

Relatively high significant correlations were found between the quality of the learning experience and the acquisition of competences. *Knowledge processing* and the assessment of the learning experience in all four learning opportunities correlated in a medium range ($.33 < r_{Know} < .66$). *Systematic competence* and *Communication competence* and *Casework, LMS and Forum discussions* also correlated in a medium range ($.34 < r_{Syst} < .54$, $.30 < r_{Comm} < .46$). *Personal competence* correlated with *Casework, Lecture, LMS and Forum discussions* in a medium range ($.45 < r_{Pers} < .57$). For *Team competence* no significant correlation could be shown with the assessed quality of the learning experience in the four learning opportunities.

For the most part, the assessment of the quality of the learning experience in the four learning opportunities *Casework, Lecture, LMS and Forum discussion* did not show significant correlations; only the *Lecture* correlated significantly in a medium range with *Casework* ($r = .50$; $p < .05$) and *LMS* correlated significantly in a medium range with *Forum discussions* ($r = .41$; $p < .05$).

The correlations and descriptive statistics for all variables can be found in Table 2.

Table 2 Correlations and und descriptive statistics

	1	2	3	4	5	6	7	8	9	<i>M</i>	<i>SD</i>	<i>N</i>
1 Casework	1	.50	.15	.25	.66	.50	.40	.17	.55	3.76	0.84	46
2 Lecture		1	.26	.23	.50	.19	.18	.25	.45	4.48	0.51	46
3 LMS			1	.41	.48	.34	.30	.05	.50	3.77	1.03	46
4 Forum discussions				1	.33	.30	.46	.07	.57	3.34	0.97	46
5 Knowledge processing					1	.54	.46	.25	.61	3.41	0.62	46
6 Systematic competence						1	.64	−.03	.64	2.71	1.00	45
7 Communication competence							1	.03	.61	2.30	1.00	46
8 Cooperation competence								1	.25	4.43	0.98	40
9 Personal competence									1	3.24	0.89	46

bold = $p < .05$

In order to test the hypotheses (H1-H5), independent regression models were calculated for every competence dimension. The results of the regression analyses are summarized in Table 3. All results are presented as standardized beta-coefficients.

The self-assessed acquisition of *Knowledge processing*, *Systematic competence*, *Communication competence* and *Personal competence* was significantly influenced by *Casework* ($.39 < b < .49$, $.001 < p < .040$). This means: A more positive learner attitude towards working with authentic cases led to better self-perceived acquisition of knowledge processing, systematic, communication and personal competence.

In addition to being predicted by the variable *Casework*, both *Communication competence* and *Personal competence* were predicted by *Forum discussions* ($b = .40$, $p = .010$; $b = .42$, $p < .001$). This means: A more positive attitude towards using forum discussions as learning opportunities led to better self-perceived acquisition of communication and personal competence.

In addition to *Casework*, the variable *LMS* predicted the acquisition of *Knowledge processing* in model 1 ($b = .26$, $p = .020$). This means: A more positive assessment of the quality of the learning experience when using the LMS as additional learning resource led to better self-perceived acquisition of knowledge processing.

None of the models showed an effect for the variable *Lecture*, and none of the considered variables significantly predicted the acquisition of *Team competence*. This means: Although learners assessed the quality of the learning experience in the lecture as high, this did not influence their perceived competence acquisition. Students considered acquisition of team competence during the course to be high. However, this cannot be systematically traced back to any effect from the perceived quality of the learning experience in any of the evaluated learning opportunities.

With regard to the quality of the estimated values, the predictors in all four significant models had a variance inflation factor less than 5, $VIF_{\max} = 1.45$; the predictors' tolerance is greater than 0.25, $T_{\min} = 0.69$. Based on these values, validity issues due to problems based on multicollinearity can be largely excluded. In addition, most predictors do not correlate, or only correlate within the moderate range, so that problems based on multicollinearity are negligible. Neither visual inspection of the

Table 3 Regression analyses

Models	ΔR^2	<i>b</i>	<i>SE_b</i>	<i>p</i>	<i>N</i>
1 Knowledge processing	.57			.000	46
Casework		.49	.09	>.001	
Lecture		.16	.57	.188	
LMS		.28	.07	.020	
Forum discussions		.10	.07	.402	
2 Systematic competence	.30			.006	44
Casework		.45	.18	.006	
Lecture		−.12	.30	.457	
LMS		.17	.14	.255	
Forum discussions		.20	.15	.187	
3 Communication competence	.30			.004	45
Casework		.33	.18	.036	
Lecture		−.10	.30	.515	
LMS		.07	.14	.638	
Forum discussions		.40	.15	.009	
4 Cooperation competence	.07			.655	40
Casework		.06	.22	.771	
Lecture		.22	.37	.273	
LMS		−.02	.17	.933	
Forum discussions		.02	.18	.932	
5 Personal competence	.58			>.000	45
Casework		.39	.13	.002	
Lecture		.11	.21	.383	
LMS		.16	.10	.163	
Forum discussions		.42	.10	.001	

bold = $p < .001$

fitted standardized estimated values on the standardized residuals, nor application of the Glejser procedure (Glejser 1969) indicated significant deviations in homoscedasticity.

5 Discussion

The present study investigated how competence acquisition in an inquiry- and ICT-supported course in a PBL format was influenced by the perceived quality of the learning experience in four learning opportunities: Working with authentic cases (variable *Casework*), participation in the lecture (variable *Lecture*), the usage of LMS as an additional learning resource (variable *LMS*) and the use of forum discussions for mutual exchange regarding the learning content (variable *Forum discussions*).

Summing up, the results confirmed the assumed connection between perceived quality of learning experience and competence acquisition for face-to-face and ICT-supported elements of learning opportunities in the present study. Knowledge processing was shown to benefit from the perceived quality of the learning experience during casework and when using the LMS as an additional resource. Positive effects on

communication competence and personal competence were seen to result from casework and forum discussion. A positive effect from casework only could be demonstrated on the acquisition of systematic competence.

Now to the research question of this paper: *How do students in ICT-supported problem-based learning rate the quality of the learning experience, and how does it relate to the acquisition of competences?* The present findings indicate that neither face-to-face nor ICT-supported elements need necessarily yield disadvantages for students' competence acquisitions. Both the variable *Casework* (face-to-face activity) and the variables *LMS* and *Forum discussions* predicted competence acquisition in the present models. The specific predictive value of these variables thereby is mostly consistent with educational theory or recent findings on ICT use in education.

Easiest to interpret is the effect of *Casework* on the acquisition of *Knowledge processing*, since it substantiates the claim of many educational theorists that authentic casework can be a powerful means for extensive knowledge acquisition by fostering the integration of new information into existing knowledge structures (e.g. Hmelo-Silver 2004). Additionally, and not surprising given that positive attitudes increase the likelihood of behavior (Aijzen 2001), students with a positive attitude towards the LMS made more frequent use of this additional learning resource. This explains the effect of *LMS* on the acquisition of the same variable. The learning resources provided in the LMS focused strongly on facilitating knowledge processing (lecture notes, video recordings of the lecture, additional documents and references), which might have favored higher acquisition of knowledge processing competences.

Also, with regard to the acquisition of *Systematic competence*, the potential of authentic casework as a competence-fostering learning opportunity was confirmed by a significant effect on the acquisition of this competence. This substantiates the claim that working with cases or “problems” is a powerful means to build a dynamic and flexible knowledge base through the integration of new information into existing cognitive structures (Hmelo-Silver 2004). The missing effect of *LMS* on systematic competence is congruent with the inconsistent results in some previous studies (e.g. Hillen and Päivärinta 2012), in which a positive effect from the mere usage of LMS-tools on systematic competence acquisition could not be demonstrated; rather, the nature and complexity of the tools had an influence (e.g. Zanjani et al. 2016).

Values of the variable *Communication competence* were predicted by the variables *Casework* and *Forum discussions*. In general, casework as part of inquiry-based learning has been considered favorable for the development of communication competence because it happens in groups (e.g. Hmelo-Silver and Barrows 2008). The assumed positive influence prevailed in the present study. However, the investigated course did not benefit from the favorable effects a tutor usually has on the process (the participants had to organize their casework autonomously). The positive effect of *Forum discussions* on *Communication competence* substantiates the claim that ICT-supported communication tools can reduce learners' communication fears and strengthen confidence in their own communicative abilities (e.g. Bower et al. 2011).

For the variable *Personal competence*, that is, personal interest and motivation, the effect of *Forum discussions* exceeds that of *Casework*. This means that the attitude towards an ICT-supported communication tool influenced interest in content and self-development during the course to a higher degree than working with the authentic problems. Previous studies have shown that ICT-supported learning opportunities in

inquiry-based learning arrangements can indeed greatly strengthen intrinsic motivation and interest in the learning subject (e.g. Woltering et al. 2009). In this respect, the learners in the present study might also have benefitted from the enrichment of an inquiry-based learning arrangement with ICT-supported forum discussions.

There was no effect demonstrable for the attitude towards the variable *Lecture on Knowledge processing* or any other competence, although the ratings for this variable were generally the highest. In other words, although students rated the quality of the learning experience in this learning opportunity highly overall, this had no effect whatsoever on competence acquisition. This marks a difference to all other models computed for this study. The fact that lectures are decisively focused on knowledge transmission but not on knowledge processing (cf. e.g. Exley 2009) could account for this finding. After all, knowledge processing competence – including organizing and integrating information – is only fostered in active and engaging learning opportunities.

A limitation to the present study is the fact that the results are based on a relatively small sample. There remains a slight possibility therefore that characteristics of this specific group have systematically influenced the results. Also, from a methodological point of view, it should be noted that the distribution characteristics of the team competence scale were the only ones that did not fully comply with the requirements of the chosen method of statistical analysis. Accordingly, the corresponding results should be considered with this reservation. In terms of the implementation of PBL, the results are subject to the restriction that the casework in the present instructional design was not as structured as in many inquiry-based curricula; while such group work is traditionally supervised by a tutor and scheduled weekly, in this case the students themselves were responsible for organizing when and how intensely they worked on the problems. Only a written procedure instruction was provided, along with access to teacher feedback and facilitation in case of difficulties. Furthermore, it is possible that the participants did not evaluate the casework with regard to its potential to foster team competence. This is also reflected in the wording of the casework items, which only asks for attitudes towards this instructional learning opportunity and not for satisfaction with the work process within the group.

However, what emerges from the present analyses is an overall picture of interconnectedness between subjective satisfaction and perceived learning gains for both face-to-face and ICT-supported learning opportunities. However, this is only true if the learning opportunities enable active participation. Based on the present findings, then, it appears that the feeling of having learned comes together with the feeling of having been provided with engaging opportunities to do so, and vice versa. The quality of the learning opportunities, whether face-to-face or ICT-supported, comes with competence acquisition in areas that are closely aligned with the actual learning activities (e.g. communication competence and discussing in forums).

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