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Laura Hemker
Technische Universität Dresden, laura.hemker@tu-dresden.de

Claudia Prescher
Technische Universität Dresden, claudia.prescher@tu-dresden.de

Susanne Narciss
Technische Universität Dresden, susanne.narciss@tu-dresden.de

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The Interdisciplinary Journal of Problem-based Learning

SPECIAL ISSUE ON COMPETENCY ORIENTATION IN PROBLEM-BASED LEARNING: VOICES FROM THE FIELD

Design and Evaluation of a Problem-Based Learning Environment for Teacher Training

Laura Hemker, Claudia Prescher, and Susanne Narciss (Technische Universität Dresden)

Abstract

Problem-based learning can have a great impact on the acquisition of practical knowledge, which is a central learning aim in the field of teacher education. Therefore, we implemented a problem-based learning approach in four seminars on educational assessment. In this paper, we outline our didactic design and discuss the results of the first evaluations, which explored acceptance of the approach, learning results, and expected applicability of the acquired knowledge.

The results show benefits of the problem-based learning approach, but also room for improvement. Specifically, the use of problems from multiple contexts (theoretical foundations and direct practical application) and the flexible adaption to the learners' prior knowledge, methodological expertise, and learning goals need to be enhanced.

Keywords: problem-based learning, teacher education, didactics in higher education, PBL, university didactics, learner-oriented teaching, teacher training

Introduction

The fundamental problem of transferring theoretical knowledge and facts acquired at university adequately to the professional domain—the "theory-practice divide"—is well documented in teacher education research (Neuweg, 2011; Korthagen, 2010). Many teaching practices in the past apparently did not provide a good foundation for the acquisition of practical knowledge but rather nurtured "inert knowledge," i.e., knowledge structures that cannot be used for practical application in the actual classroom (Renkl, Mandl, & Gruber, 1996; Gruber & Renkl, 2000). The problem is known to university graduates in other professions as well (cf. Reusser, 2005), most prominently in the medical and health care sector.

The concept of "problem-based learning" (PBL; e.g., Zumbach, 2003; Loyens, Kirschner, & Paas, 2012) is expected to significantly enhance the usability of knowledge acquired at university: the transfer of theoretical knowledge to professional situations on the one hand, and the direct acquisition of practical knowledge on the other hand (e.g., Wagner et al., 2013; De Simone, 2014). The rationale for the expected effectiveness of PBL is the individually tailored acquisition of knowledge "on demand" by working on authentic and practical problems. Since knowledge is thereby gained in a very specific application context and can further be probed in multiple contexts from different perspectives, chances are good that it will also be retrieved in the relevant practical contexts. The acquisition of practical knowledge is presumably also enhanced by the situated activation of the individual's prior knowledge. Furthermore, the integration of different fields of professional knowledge (Shulman, 1987) can be improved by using problems that encompass these different fields (e.g., Kiel, Kahlert & Haag, 2011), which is of particular importance in the area of teacher education. All in all, the features mentioned above are supposed to avert any "inertness" of knowledge acquired in formal teaching activities at university.

Studies on PBL in teacher education show a rather diverse but quite consistent picture. On the one hand, the PBL approach does seem to support strong theory-practice alignment, as observed in various forms of PBL implementations

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Table 1. The 7-step method (cf. Schmidt, 1983, p. 51; Weber, 2005, p. 97).

1st Problem Analysis	
1.	Clarify terms and concepts not readily comprehensible
2.	Define the problem
3.	Analyze the problem
4.	Draw a systematic inventory of the explanations inferred from step 3
5.	Formulate learning objectives
Phase of Knowledge Acquisition	
6.	Collect additional information outside the group
In-Depth Problem Analysis	
7.	Synthesize and test the newly acquired information

through measures of student self-report (e.g., Wilhelm & Brovelli, 2009; Zinn & Faßhauer, 2012; Scholkmann & Küng, 2016) and through actual testing of the acquired skills (Wagner et al., 2013; De Simone, 2008). On the other hand, there are well-acknowledged challenges, most notably the high demand on the learners' time and effort, and learners' potential difficulties to adjust to a new, rather different teaching approach (De Simone, 2008; 2014; Patrick & McPhee, 2014). Both issues can affect the students' satisfaction and commitment, and ultimately their learning gains. However, strong instructional guidance during the whole PBL process seems to be a good remedy (e.g., Vardi & Ciccarelli, 2008).

Based on these considerations, we have planned, implemented, and evaluated a problem-based learning environment on the topic of "educational assessment" in the first university-based phase of teacher education.[1] In the process, we integrated PBL into existing teaching structures without changing the overall curriculum (i.e., "small-scale implementation"). In this paper, we present the instructional design of our problem-based seminars and the results of the first formative evaluations.

Conception of the PBL Environment

PBL Model and Position in the Curriculum

We planned our seminars according to the critical analyses of the criteria for effective and fruitful PBL implementation (e.g., Hmelo-Silver, Duncan & Chinn, 2007; Müller Werder, 2008; Hung, 2011). For the specific learning group of aspiring teachers and their particular instructional needs, we used a PBL model designed to foster the acquisition of well-structured, practical knowledge, above all. The PBL model used in our seminars has been termed "closed loop or reiterative problem-based" learning (Barrows, 1986, p. 484).

Following the 7-step method (see Table 1), the problem cases are discussed in small study groups (PBL steps 1–5). After a phase of individual, self-regulated study and research (step 6), the group reappraises the originally presented problem, in order to synthesize and test the newly acquired information (step 7). At this stage, students also evaluate their prior reasoning, knowledge, and problem-solving skills, in order to better comprehend the particular value of the new information.

The overall sequence of the problem presentations during seminars is determined by the lecturers, based on didactic criteria like thematic progression and consistency of the particular problem space. The problems presented are rather well structured and comparatively complete.

The seminars described in the following all deal with the topic of educational assessment. Central learning aims include knowledge about relevant research approaches, methods, and results of applied psychological research, as well as the ability to use this knowledge to deduce reasonable consequences for the design of learning environments at school. The seminars are offered as compulsory elective modules in the teacher education program for different school subjects and school types (master's level). Before attending the seminars, students have to successfully complete two required lectures on educational psychology. Several topics of the seminars are already treated in those lectures.

Construction of the Problem-Based Learning Cases

Seven problem-based learning cases were constructed (200–500 words), all dealing with central aspects of teachers' knowledge and competencies in the field of assessment.

1. Teacher training in Germany is generally divided into two consecutive stages: a higher education course (at university) and practical pedagogical training (at school). Even though the first phase of teacher education mainly aims at the establishment of a solid base of theoretical knowledge, this knowledge should naturally be utilized in the next phase of practical training and profitably linked to experiences in the field.

Sources of the problem descriptions were workbooks for aspiring teachers (Kiel et al., 2011; Kiel & Pollak, 2011) and textbooks in educational psychology (Zumbach & Mandl, 2007; Woolfolk & Schönpflug, 2008).

Three to four problems each deal with one of several subject areas at a time (e.g., standardized testing, usage of individual reference standards) in order to foster the flexibility of the acquired knowledge. At the same time, each problem comprises more than one subject area, in order to establish connections between different topics and knowledge areas. Each narratively structured problem presents an acute case of a teacher, which requires a decision and an action. Mostly, dilemma situations typical for the teaching profession are used, which also reflect the structural uncertainty of action decisions in the teaching profession (e.g., "General performance requirements or individual assessment"; Kiel & Pollak, 2011, p. 214). All problem cases are clearly structured, descriptively presented, and contextually well embedded.

As a focal point of the seminar work, we positioned the development of an "assessment plan" for the students' own future teaching activities in their specific school subjects (based on Woolfolk & Schönpflug, 2008, p. 676; see Figure 1). At best, the assessment plan sets out in writing the goals, guiding principles, and special agreements about evaluation and examination practices in one particular subject (Sacher, 2009, p. 265). The handling of this complex problem demands the integration of pedagogical, methodological, and subject-specific content knowledge. At best, the respective problem solution provides a useful foundation for actual corresponding plans for the students' future teaching practice. Table 2 (next page) exemplarily shows an excerpt from a students' solution.

Seminar Schedule

The introductory session of the seminar provides a content-oriented and an organizational introduction where the instructors explain the educational principles and the implementation of PBL. The second session starts by working on the problem cases in small working groups (3–5 students per group), assigned on the basis of similar subjects and types of school.

Following the group work with a duration of typically two seminar sessions, each group presents their solution to the complete seminar assembly for discussion and criticism. The particular problems the groups worked on were chosen based on interest, learning objectives, and a reasonable fit within the overall group. However, as the central problem and outcome of the seminar work, the development of an assessment plan was assigned to each group.

In detail, PBL was field-tested by two instructors (see Table 1). In order to take into account that teachers develop personal preferences and teaching habits, the PBL concept was implemented with two slightly different setups. Seminars A and B start with various problems for the individual groups (sessions 2–5, see Table 1), and develop the subject-specific assessment plan in the last phase of the seminar work. In contrast, seminars C and D start out with a first draft of the assessment plan, then work on the different problems, and finally return to the initial assessment plan in order to review and improve the first draft. However, no effects of the alternative

Problem Case: Assessment Plan

As a teacher, you will have to assess students' work by using the established school grades, one to six. These figures must be put on all tests and examinations, and on the report cards, above all.

Some teachers assess only completed assignments, while others also evaluate progress and acknowledge even minor steps and achievements. Some teachers mainly rely on social reference standards (i.e., social comparison), while others assess more individually, by giving credit for the individual's advancement or apparent effort. Some would prefer to give only verbal feedback, while others like the clarity of scores and grades.

Everyone involved strives for an assessment system that is fair, manageable, and transparent for everyone involved: students, parents, fellow teachers, and also the following schools and future em-ployers. At the same time, the assessment is supposed to foster learning, being more than just a final judgment on performances. Students should receive feedback that helps them to improve and moti-vates them. Few aspects of assessment are regulated centrally; the actual practice and implementation mostly remain in the hands of the individual teacher.

Task: Outline an assessment plan for your future teaching activities in one specific school subject area (e.g., history, biology, etc.). Describe why your assessments are useful for measuring learning. Because discussion and agreement with colleagues are indispensable at school, you are working in teams here as well.

Figure 1. Representation of the problem case "Assessment Plan" (adapted from Woolfolk & Schönpflug, 2008, p. 676; translation by the authors).

Table 2. Excerpt from an Exemplary Students' Assessment Plan (translated by the authors).

Exemplary Assessment Plan (Excerpt From Students' Solution for the Task) **Topic:** Assessment of group work (School subject: humanities; Task: poster design & presentation)	
Initial Plan:	Group grade for poster (50%) + Individual grade for oral poster presentation (50%)
Problem Areas:	Transparency – Equity – Fairness – Motivation – Recognition of group processes – Recognition of individual effort – Clarification of learning goals – Cooperation – Competition – Rivalry
Learning Questions:	How should the grades be allocated between the final group product, individual contribution, and the cooperative group process? • Which assessment encourages effective group work? • How can information on the contribution of each group member be obtained? • Is it feasible to grade group work within the school system of individually allocated grades? (school law) • Which rubrics are advisable for the assessment of group work?
Revised Plan:	Group grade for poster (50%) + Individual grade for oral poster presentation (50%); Alternatively: Individual grade for written report Additionally: Regular feedback on group processes Formative self and peer assessment of team work skills

implementations could be observed, so the specific rationale for each setup will not be further discussed at this point.

Instructional Support

Various forms of instructional support seem necessary to prevent potentially excessive demands of the unfamiliar learning environment (cf. Müller Werder, 2008; Hung, 2011). The following support options are provided in the seminars:

Organizational support

- Teaching the 7-step method for cooperative problem-solving
- Precise instructions and specific task assignments for the cooperative work
- Clear schedule for the cooperative work
- Seminar website with literature, source references, and further links and information

Face-to-face support

- Intermittent support and guidance by the teachers
- Step-by-step guidance through the first PBL process
- Feedback on interim results from lecturers and fellow students
- Two teacher-centered seminar sessions with specific consolidation and application tasks (seminars C and D)

Adjustment of performance assessment

Because the method of performance evaluation has a significant effect on the students' learning (cf. Müller Werder, 2008), several measures are taken in order to explicitly acknowledge the particular learning processes pursued by the introduction of problem-based learning. Thus, the students draw up a "problem report" in which they present and reflect on the theoretical background of their problem solutions as well as on the cooperative work process itself. The reports are assessed based on a list of criteria previously explained to the students. In addition, the learning success is controlled and secured informally and formatively through the presentation and discussion of interim results and through extensive feedback during the separate seminar sessions.

Table 3. Schedule of the seminars; steps of the problem-solving process are labeled (cf. Weber, 2005, cf. p. 5).

Session No.	Seminars A and B	Seminars C and D
1	Introduction	Introduction
2	Steps 1–5: Different problems	Steps 1–5: Assessment Concept
3	Step 6: Research, Consultation	Step 6: Research, Consultation
4	Step 7: Synthesis, Presentation, Discussion	Step 7: Synthesis, Presentation, Discussion
5	Step 7: Presentation, Discussion, Case Evaluation	Extra Step: Consolidation and Application (Teacher-Centered)
6	Steps 1–5: Assessment Concept	Steps 1–5: Different Problems
7	Step 6: Research, Consultation	Step 6: Research, Consultation, Synthesis
8	Step 6: Research, Consultation	Step 7: Presentation, Discussion
9	Step 7: Synthesis	Step 7: Presentation, Discussion
10	Step 7: Presentation, Discussion	Step 7: Presentation, Discussion
11	Step 7: Presentation, Discussion	Extra Step: Consolidation and Application (Teacher-Centered)
12	Step 7: Presentation, Discussion, Evaluation	Summary and Evaluation

Experiences

Method and Data Pool

In total, four problem-based seminars were conducted and evaluated formatively, i.e., with the aim of optimizing our didactic approach (Scriven, 1967).

Questionnaire-based data (adapted from Rindermann, 2009; Nitsche, 2003) concerning (a) acceptance of the seminar concept, (b) perceived learning success, and (c) expected transfer of learning to behavior (transfer expectations; i.e., the participants' expectation of applying the new knowledge and changing their behavior on the job) were collected in the first and the last session of each seminar in both studies. A single-group pretest-posttest design was used as a means of identifying potential improvements. Accordingly, the following presentation of results focuses on the most striking and salient insights about improvement opportunities.

Sixteen students participated in seminar A (13 completed questionnaires), and 18 in seminar B (10 completed questionnaires). Seminar C had 18 and seminar D 20 participants. The data from seminars C and D were analyzed together. Sixteen participants completed all questionnaires and were thus included in the subsequent analysis.

Results

Satisfaction with the didactic approach

The questionnaires consisted of statements on different aspects of the seminar design, contents, and educational approach (e.g., "The seminar contents are consistent with my learning aims"). Overall, the seminars were evaluated positively in this category.

However, comparing the expectations at the beginning of seminar B with the respective ratings at the end of the semester, the very high initial expectations for the PBL concept have not been met for all participants of the seminar. Except for the item "good use of my prior knowledge," all statements were rated more critically than initially (e.g., "appropriateness of the task difficulty," "provision of new insights and methods," "exciting and interesting topics," and "appropriateness of the time expenditure"). Possibly, these results can be explained by the unfamiliar concept of the seminar: no direct instruction and a heavy focus on self-regulated, independent learning (cf. De Simone, 2014). It also seems interesting to systematically explore the relevance of these satisfaction measures for the overall success in terms of knowledge, skills, and effective transfer of learning to the classroom in future experiments.

Perceived learning success

The participants rated their state of knowledge in seminars B, C, & D in the beginning and directly after completion of the semester. In all seminars, participants reported a (mostly significant) increase of knowledge. Various test questions and tasks from the catalog of learning objectives confirm these subjective assessments.

When asked for a comprehensive evaluation of their knowledge gain after completion of the seminar work (only in seminars C and D); however, 9 out of 16 participants rated their prior knowledge as "too little" for the work expected in the seminar, 7 as "appropriate" (answer options: no/too little/appropriate). A likely explanation for this pattern in seminars C and D is the choice of a very complex problem right at the start of the seminar work, while the students still had to come to grips with a new method of seminar work. More specifically, 11 out of 16 were "content" with their knowledge gain during the seminar, while 5 stated that they had learned "too little" content (answer options: satisfied/too little content/too much content). However, there was no statistical connection ($\chi^2 = 1.66$; $p = .231$) between both ratings, i.e., students who rated their prior knowledge as "too little" did not assess their knowledge gain as particularly negative.

Both findings show rather typical difficulties with problem-based teaching events, which even the various measures of instructional support apparently could not prevent completely.

Expected transfer of learning to behavior

In all seminars, the participants were asked to assess the expected transfer of learning to behavior at the beginning and after the conclusion of the seminar: How far did they expect to apply what they learned in their further studies and in the teaching profession?

Interestingly, the expectation of knowledge transfer was rather high when the students assessed their work on the individual problems. For the entire seminar, however, the expectations were only high in the beginning but dropped to average/medium at the end of the semester. This result might be explained by a potentially insufficient consolidation of the acquired knowledge, resulting in students remembering too few details and connections over time. For the future, a guided documentation of learning outcomes is planned to support the consolidation of knowledge.

Conclusion

To improve the acquisition of practical knowledge in university-based teacher training, we integrated PBL into single seminars. Our first experiences show that students welcome the work with realistic, practical problems and expect positive outcomes from the PBL concept. At the same time, our experiences show opportunities for optimization of the didactic design, which will be taken into account for the further development of our seminar design, and may also be generally helpful for the development and organization of other PBL-based teaching events.

Better Adjustment to Heterogeneous Students' Characteristics

In our seminars, the heterogeneity of the learners' prior knowledge posed a challenge, as several students did not perceive their own prior knowledge as adequate for the PBL process. This problem could possibly be prevented by more closely guided text work or, alternatively, a central presentation at the beginning of the seminar, to provide students with a better overview of the field of knowledge and support the acquisition of conceptual knowledge (De Simone, 2008). Another option would be to present exemplary solutions for the problem cases (cf. Zumbach & Mandl, 2007). This might be particularly useful for the task of developing an assessment concept, which seems rather complex for most learners. In this respect, the establishment of online learning resources might be a promising route (cf. Loyens et al., 2012), and it might even help to narrow the gap between learners with high and low prior knowledge levels.

Problem Cases for Direct Application of Acquired Knowledge

Even though the students assessed the problems used as very realistic and interesting, the solutions developed in the PBL process were often not elaborated on a level that would enable the direct transfer to behavior on the job, but rather on a more abstract level. For this reason, two of the seminars (C and D) have already been supplemented by an additional work step, where students learn to put into practice the often more abstract solutions developed for problem cases (e.g., conduct a conversation with parents). This step was assessed as very helpful by the participants, and it will, therefore, be given more place and weight in future seminar concepts. An even better measure seems to be the direct link to real teaching experiences, which has had beneficial effects on learners' motivation and personal involvement (cf. Zinn & Faßhauer, 2012; Fraefel, Bernhardsson-Laros, & Bäuerlein, 2016).

Bottom Line: More Support for (Some) Learners

To sum up, a stronger structuring of the learning processes and a more effective supervision of the individual's learning success seem conducive to more satisfaction and better learning gains. To this end, even more elements of instructional support may need to be implemented (Kirschner & Merriënboer, 2008; Müller Werder, 2008). The development of new knowledge by working on authentic problems as such will be kept at the center of the seminar work. However, more flexible variants of PBL

with different levels of instructional support will be applied, depending on individual learners' skills and competencies (cf. Hung, 2011; Zumbach & Mandl, 2007), to better support the development from guided instruction toward lifelong, independent, and self-organized learning for all learners.

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Laura Hemker received her PhD in psychology from the University of Bonn. She has been working as a postdoctoral researcher in the Department of Psychology of Learning and Instruction at Technische Universität Dresden. Her current research interests focus on learning strategies, teacher training, and educational assessment.

Claudia Prescher is a scientific associate at the Department of Psychology of Learning and Instruction at Technische Universität Dresden. She is involved in teacher training in educational psychology. Her research interests include teaching and learning practices, problem-based learning, and measuring and assessing learners' performance.

Susanne Narciss is full professor and head of the research team "Psychology of Learning and Instruction (PsyLI)" at Technische Universität Dresden. The PsyLI team is conducting theory-driven and design-based psychological research on issues related to lifelong learning and instruction within sociotechnical systems. Narciss received her PhD from Heidelberg University in 1993. From 1994 until March 2014 she worked at TU Dresden as assistant and associate professor. From April 2014 until September 2015 she was a full professor of psychology at the University of Passau. Her current interests include research on promoting self-regulated learning, the role of motivation and metacognition in instructional contexts, and conditions and effects of informative tutoring feedback. Her work on feedback strategies was considered cutting edge by the American Association on Educational Communication and Technology (AECT) and awarded the prestigious AECT Distinguished Development Award in 2007.