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Increasing perceived relevance of the required content knowledge

Lack of Motivation and Study Discontinuation

In Germany, dropout rates among physics and pre-service physics teachers remain particularly high (Heublein, Hutzsch, Schreiber, Sommer, & Besuch, 2010) where a high shortage of physics teacher is expected (Klemm, 2015). The problem lies partly in the learning motivation of pre-service physics teachers (PST). They often struggle to see the connection between the university content knowledge and the content knowledge they will need as a teacher. At the same time, evaluations of the teacher training courses at the University of Potsdam showed, that PST students want for a more noticeable connection between the physics content courses and the physics education courses (AG Studienqualität, 2011). Studies at other institutes show that there is general validity to his problem (e.g. Koponen, Asikainen, Viholainen, & Hirvonen, 2016). There exists a positive correlation between perceived relevance and both learning outcomes, the conceptual understanding level (Deci, Eghrari, Patrick, & Leone, 1994; Deci, Vallerand, Pelletier, & Ryan, 1991) and motivation (e.g. Keller, 1983). A separation from the professional field and lack of motivation are furthermore seen as study discontinuation reasons (Heublein et al., 2010). Therefore, there is a need for action.

Professional Knowledge of Physics Teachers

The professional knowledge of (prospective) teachers has been extensively described by Shulman (1986). Content knowledge (CK) was differentiated from pedagogical knowledge (PK) and pedagogical content knowledge (PCK). In multiple studies, the latter has been described in detail (e.g. Gess-Newsome, 2015). CK plays a vital role in the acquisition of PCK (Baumert et al., 2010; Krauss et al., 2008; Terhart, 2002). However, it remains unclear, what and how much CK (prospective) teachers need. In several studies of the professional knowledge of (prospective) teachers (e.g. Ball, Thames, & Phelps, 2008; Heinze, Dreher, Lindmeier, & Niemand, 2016; Loch, 2015; Riese, 2009), the content knowledge has been further specified. A knowledge category emerged that describes the teacher-specific content knowledge. However, the current definitions of this category are subject-specific and only include the substantive structure and not the syntactic structure of content knowledge (Schwab, 1964, 1978, Shulman, 1986, 1987). For several subjects, the *school-related content knowledge* (SRCK) has been modeled within the project PSI-Potsdam in a multi-disciplinary group, taking both the substantive and syntactic structure into account (Massolt & Borowski, 2017; Woehlecke et al., 2017). SRCK describes a conceptual knowledge and is characterized by networked knowledge. It is necessary for a more thorough understanding of content that is relevant in school-situations; SRCK describes knowledge and abilities that prepare for the planning, teaching and analysis of physics lessons.

Research Question

University physics courses in Germany typically consist of lectures, laboratory experiments and tutorial groups. In the latter, weekly problem sets are discussed. Tutorials serve as an important preparation for the final exams. Two new conceptual problems have been developed as part of the regular problem sets discussed in tutorial groups. One of these problems base on the knowledge and abilities described in SRCK; the other problem is a conceptual problem without school relevance. As a preparation for the weekly tutorial sessions, both physics majors and pre-service physics teachers solve the problems on these

problem sets. This research question we ask is: to what extent do pre-service physics teachers perceive the SRCK-based problems as more relevant than the regular problems? We expect that a focus on SRCK increases the perceived relevance of the university content knowledge (e.g. Keller, 1983) by the pre-service physics teachers. The problem sets are however a very important preparation for the final exam. They are also aimed at both physics majors and pre-service physics teachers. Therefore, the problems based on SRCK should be at the same level as the regular problems.

Design

Two out of five of the regular problems on weekly problem sets part of two first year experimental physics courses were replaced (WiSe2016/2017: Experimental physics 1 (Newtonian mechanics), N = 28 physics majors, N = 47 physics PST; SuSe2017: Experimental physics 2 (Electricity & Magnetism), N = 19 physics majors, N = 24 physics PST). The two new problems are both conceptual problems. Only one of them is based on the knowledge and abilities described in the SRCK model; the other problem is a conceptual problem without explicit school relevance. The assignment of problems to the three different problem types (regular, conceptual based on SRCK and conceptual without school relevance) was done using a problem design manual ($\kappa = 0.80 / 0.78$).

Under the same conditions, both the regular problems and the new problems were solved at home and subsequently discussed in tutorial groups. At the beginning of every tutorial session (for a total of 13 weeks), all the students were asked to complete a questionnaire where they had to rate the problems (on a scale from 1 to 6) with regard to difficulty and relevance for their later occupation. Because of time restrictions, we used a single-item measure for relevance. A study (after de Boer et al., 2004) with N = 32 students showed that this single item correlates strongly (r = .76, p < .001) with the multiple-item 'value/usefulness' scale from the intrinsic motivation inventory (Deci & Ryan, 2003).

Results

The results of the first semester can be found in figure 1. An analysis using an unpaired t-test shows, that the questions based on SRCK are perceived as more relevant by pre-service physics teachers than by physics majors $p < .001$; $d = 2.25$. The conceptual problems without school relevance were also perceived as more relevant by pre-service physics teachers than by physics majors ($p < .001$), the effect size was however much smaller: $d = 1.22$.

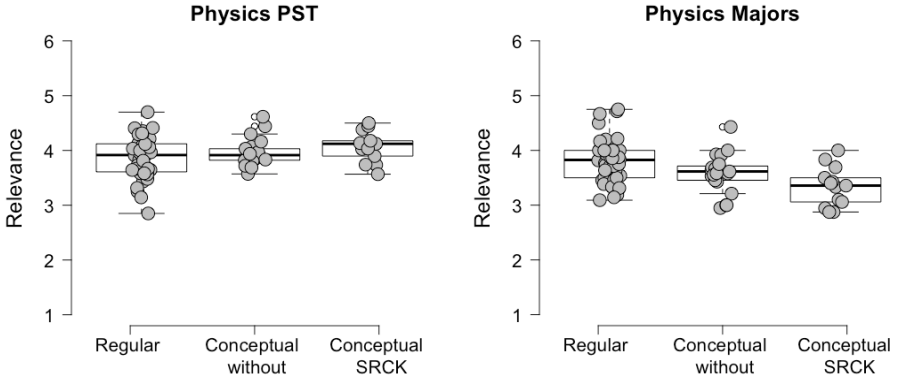

Fig. 1, Experimental physics 1, perceived relevance per problem separated by problem type by pre-service physics teachers (left) and physics majors. A higher number means a higher perceived relevance.

Analysis of variance between the problem types showed no statistical significant differences in perceived relevance by pre-service physics teachers, $F(2,71) = 1.91$, $p = .16$. The difference in difficulty was also not statistically significant, $F(2,71) = 3.02$, $p = .055$.
The physics of the last part of the semester is more distant to school physics; here, an analysis of variance shows an effect of problem type on perceived relevance, $F(2,21) = 4.58$, $p < .05$. A Tukey's HSD posthoc analysis showed that the perceived relevance of the SRCK-Problems was significantly higher than the regular problems ($p < 0.05$). Significant differences between the other problem types and in difficulty were not found, $F(2,21) = 0.18$, $p = .84$.
In the second semester, a similar analysis of variance between the problem types showed significant differences in the perceived relevance by pre-service physics teachers, $F(2,74) = 12.34$; $p < .001$. Using the HSD posthoc analysis, significant differences were found between the regular problems and the conceptual problems without school relevance ($p < .01$) and between the regular problems and the problems based on SRCK ($p < .001$).

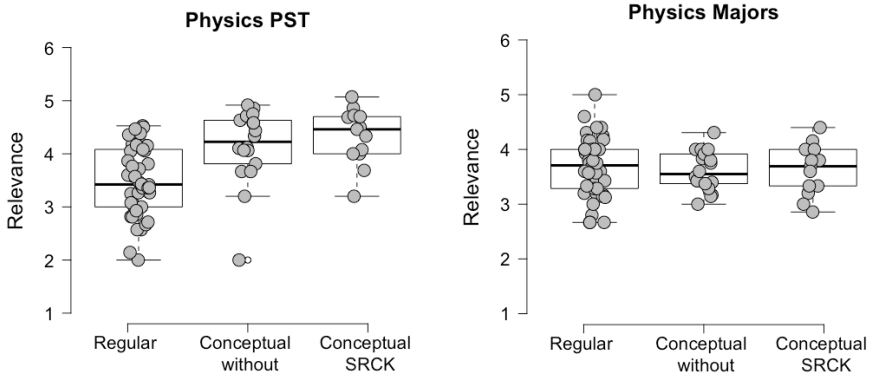

Fig. 2, Experimental physics 2, perceived relevance per problem separated by problem type by pre-service physics teachers (left) and physics majors

Discussion and Conclusion

The results show that the pre-service physics teachers perceive the problems based on SRCK as more relevant than physics majors do. These results support our theory that SRCK describes a knowledge that is important for physics teachers, which makes the problems based on SRCK more relevant to the pre-service physics teachers.
In the final third of the first semester and in the second semester, where the content is more distant to school physics, the problems based on SRCK are perceived as more relevant to pre-service physics teachers. There are however no significant differences between the conceptual problems with and without school relevance.
We can therefore conclude that problems on problem sets offer us a possibility to increase the perceived relevance of the university content knowledge by pre-service physics teachers. However, given the limitations that these problems have only been evaluated at one university and within one group of students, further research is necessary.

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