Upper secondary teachers’ *stages of concern* related to curricular innovations before and after a professional development course on teaching probability and statistics including the use of digital tools

Rolf Biehler and Ralf Nieszporek

Paderborn University, Germany; biehler@math.upb.de, ralf.nieszporek@math.upb.de

In 2013 the German Centre for Mathematics Teachers Education (DZLM) developed a professional development course called “stochastics compact”. This course was held three times between 2013 and 2015 and reached over 270 teachers. One of its goals was to increase upper secondary teachers’ competence of teaching probability and statistics in combination with the use of graphic calculators (GC). Part of the research was to examine the *stages of concern (SoC)* linked to the implementation. Multiple-choice questionnaires were used as a survey method. In this paper, we present two selected preliminary findings. At first we compare the SoC in the three courses 2013, 2014 and 2015 including the four cluster profiles we have identified. After that we present the changes of SoC and the migration between the clusters while participating in the course of 2015.

**Keywords:** Professional development, stages of concern, probability and statistic, graphic calculator

**Context of the professional development course**

Our research is related to three four-day (spread over several months) professional development course on teaching probability and statistics at upper secondary schools (grade 10 -12) in the German federal state of North Rhine-Westphalia (NRW) in 2013, 2014 and 2015. Over 270 teachers participated in the course. Due to new national standards (KMK, 2012) and subsequent new state curricula in NRW, probability and statistics are now an obligatory part of the curriculum and the final examination (Abitur). Moreover, the use of graphic calculators has become obligatory in the classroom and in the examinations. This was a challenge for most teachers and caused sustained need for professional development. The German Center for Mathematics Teacher Education (DZLM) recognized this need and gathered a team of experienced school teachers and researchers to originate a professional development course called “stochastics compact”(Biehler, 2016). The design of this course is based on results from stochastics education (Biehler, Ben-Zvi, Bakker, & Makar, 2013; Burrill & Biehler, 2011; Oesterhaus & Biehler, 2014), their interpretation of the standards and the design principles of the DZLM (Barzel & Selter, 2015). The first implementation was complete in 2013, followed by the second in 2014 and a third in 2015.

There was a fundamental difference between the 2013 course and the 2014 and 2015 courses. The 2013 course was run before the new curricula became obligatory and the graphic calculator (GC) was prescribed. The first two days were devoted to the concept probability and relative frequency, Bayes rule and conditional probability and the binomial distribution. On its third and fourth day, the 2013 course focused on an approach to the teaching of hypothesis testing that was innovative for most German teachers, focusing on p-value hypothesis testing as a start, using authentic examples from real statistical studies instead of artificial problems, and discussing possible misinterpretations of hypothesis testing that are well known from studies in school and in statistical practice. We called our approach Best@Kontext (Oesterhaus & Biehler, 2014). The 2014 and 2015 courses (after
the new state curricula) built on this approach but included more systematically the use of GC for interactive visualizations, simulations and calculations not only on the third and fourth day, when hypothesis testing remained the focus. The first and the second day were completely revised and restructured using simulation and GCs.

Accompanying research addressed the change of competences and beliefs of the participating teachers as well as teachers’ feedback to the courses they attended. Moreover we were interested in the teachers’ “stage of concern” related to the innovation. The main purpose of this article is to present results of the stages of concern questionnaire (SoC), which may be a relevant instrument for doing research on professional development courses and on teachers’ attitudes to innovations in general.

Theoretical framework and related research on the Stages of Concern

The research of interests and concerns of teachers described in this article is based on the Concern-Based Adoption Model (CBAM). This model was developed by the Research and Development Center for Teacher Education at the University of Texas in the early 1970s (Hall, Wallace, & Dosset, 1973). It is partly based on Fuller’s work on concerns of teachers (Fuller, 1969). One of the three diagnostic dimensions of CBMA is the Stages of Concern Model. It is a framework which helps to understand the personal aspects of adopting an innovation and the connected change progress. The researchers of the University of Texas identified seven stages (see Table 1) which a person passes through while implementing an innovation.

<table>
<thead>
<tr>
<th>Stages of Concern</th>
<th>Label</th>
<th>Example item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self</td>
<td>0 Unconcerned</td>
<td>I am more concerned about another innovation.</td>
</tr>
<tr>
<td></td>
<td>I Informational</td>
<td>I would like to know how this innovation is better than what we have now.</td>
</tr>
<tr>
<td></td>
<td>II Personal</td>
<td>I would like to know the effect of the innovation on my professional status.</td>
</tr>
<tr>
<td>Task</td>
<td>III Management</td>
<td>I am concerned about time spent working with non-academic problems related to this innovation.</td>
</tr>
<tr>
<td>Impact</td>
<td>IV Consequence</td>
<td>I am concerned about how the innovation affects students.</td>
</tr>
<tr>
<td></td>
<td>V Collaboration</td>
<td>I would like to develop working relationships with both our faculty and outside faculty using this innovation.</td>
</tr>
<tr>
<td></td>
<td>VI Refocusing</td>
<td>I now know of some other approaches that might work better.</td>
</tr>
</tbody>
</table>

Table 1: Typical items of the different Stages of Concern, based on George et al. (2008)

1 The development process of the SoC-Model is described in greater detail in George, Hall, Stiegelbauer, and Litke (2008). There an elaborated definition of the term SoC can be found.
We decided to use the standardized SoC questionnaire of Hall and his team (Hall & Hord, 2006) with 35 multiple-choice questions, five for each per stage (see Table 1 for example items for each stage). As Hall points out, changing anything besides the word “innovation”\(^2\) will risk the reliability and validity of the items (see Schaafsma and Athanasou (1994) as a negative example). A qualitative approach with interviews would have been difficult to implement in the framework of our courses. Using the SoC questionnaire allows comparisons to other studies (see below). In addition, we used other questionnaires more specific to the contents of the course, but we will report on the results elsewhere.

The course “stochastics compact” took place in Germany, so there was a need for a German translation of the English SoC questionnaire. We used the translation compiled Pant, Vock, Pöhlmann, and Köller (2008a)\(^3\).

One of the first studies of SoC was executed by Hall, George, and Rutherford (1977). The researchers identified several profiles and their characteristic graphical shape. These profiles were the basis for other SoC research like Liu and Huang (2005), who examined American teachers and their problems related to the integration of technology. They found that the greatest concerns depend on the teachers’ experience. Inexperienced teachers tend to have personal and informational concerns, while experienced teachers were mainly concerned about the consequences for their students, and renewing\(^4\) educators placed their focus on collaboration and refocusing concerns. A second finding was that the strongest concerns were in the stages of personal, informational and refocusing concerns. The three above mentioned SoC profiles that were re-identified by Liu and Huang and had been first constructed by Hall et al. (1977). A second survey regarding concerns of 659 American pre K-12 teachers about the use of technology like computers in school was conducted by Casey and Rakes (2002). Peaks in the SoC profiles were found in informational, personal and collaboration concerns. The interpretation was that school teachers are still uncomfortable and in an initial stage of understanding the benefits of technology in school. Pant, Vock, Pöhlmann, and Köller (2008b) came to the conclusion that most German elementary and middle school teachers in their study have high self and impact concerns (see Table 1) regarding the recently implemented national standards, thus they show a typical M-shaped profile (see the graph shapes in Figure 1) of a cooperator. This profile was also found by other researchers like Bitan-Friedlander, Dreyfus, and Milgrom (2004) or Pöhlmann, Pant, Frenzel, Roppelt, and Köller (2014). Bitan-Friedlander et al. were able to identify five types of SOC profiles of primary school science teachers which were confronted with the implementation of an innovation. Another result was that

\(^2\) The innovation can be replaced by the name of the innovation or other phrases which respondents are more familiar with.

\(^3\) We are grateful to Doreen Prasse for providing a copy of the German version of the questionnaire.

\(^4\) Liu and Huang defined renewing teachers as persons who understand the innovation and are adopting or thinking about different kinds of use of the innovation based on their experience.
most of the participants were able to “adopt”\textsuperscript{5} the innovation and developed a personal perception. Pöhlmann et al. (2014) chose a control group design to measure the efficiency of a newly developed intervention to help teachers who are dealing with the new German national standards for the first time. The SoC questionnaire shows at the beginning that control and test groups were on a comparable level and the participants show a high level of self-concerns. Impact concerns were secondary in both groups. After a year of training an increase in impact concerns as opposed to self-concerns was observed.

**Research question**

We will address the following research questions in this paper:

1. How do the SoC differ when a professional development (PD) course is backed up by an official obligatory innovation and not only by an innovation suggested by the PD course designers?

2. In reference to probability and statistics including the use of the GC, what types of teachers can we identify and how frequent to these types occur?

3. How does our PD course change the SoC of the participants?

These questions present just one facet of a wider research project. We used our access to the participants not only to determine their SoC levels but also to identify other important aspects which we intend to associate with the SoC-profiles in our future research.

From a methodological point of view we are interested how well the SoC scales can be used to identify characteristics and subgroups of teachers, which are important to take into account when designing and evaluating PD courses.

**Design of the study**

The SoC in 2013 were related to the third and fourth day of our course and “our own” innovation Best@Kontext, the SoC in 2014/2015 were related to the whole course and to the official state innovation of teaching probability and statistics with graphic calculators. We communicated to the teachers that our course is compatible with the new state innovations, but that our specific foci are based on research in probability and statistics education related to student difficulties, valuable teaching approaches but also on normative aspects concerning the fundamental ideas in probability and statistics that provided structure to the course.

**Data collection and data analysis**

We were able to use 38 questionnaires in 2013 (post test), 55 in 2014 (post test) and 74 in 2015 (pre and post test). The others had incomplete SoC questionnaires or could not be matched in the pre and post test.

\textsuperscript{5} Usually the term adopt means to accept a new idea and to implement the idea as one of your own. For primary school teachers in this study the meaning of adoption needed to be redefined, because they did not challenge the theoretical knowledge or ground or mentioned a personal opinion about the implementation of the innovation.
post test design of 2015. The phrasing of each items of the questionnaires were identical, except for the names of the innovation. As mentioned before this adjustment is appropriate for a SoC questionnaire. We used the manual of Hall et al. (1977) as a guideline for the program SPSS 23 for analyzing our data. Therefore our statistical analysis is comparable to the above-mentioned studies. For the determination of SoC subgroups, we used a cluster analysis of the individual subscale means. The ward method was chosen with the squared Euclidean distance as measure in every step of our analysis to divide the participants, as recommended by Bortz and Schuster (2010). The clusters were created with the data of all four measurements so that we were able to analyze shifts in the distribution of participants among the identified clusters.

Results

The reliability of the SoC subscales (see Table 2) can be compared to other studies like Pant et al. (2008b) or George et al. (2008).

<table>
<thead>
<tr>
<th>Subscale</th>
<th>0 Unconcerned</th>
<th>I Informational</th>
<th>II Personal</th>
<th>III Management</th>
<th>IV Consequence</th>
<th>V Collaboration</th>
<th>VI Refocusing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach’s α</td>
<td>0.717</td>
<td>0.560</td>
<td>0.729</td>
<td>0.727</td>
<td>0.782</td>
<td>0.836</td>
<td>0.765</td>
</tr>
</tbody>
</table>

Table 2: Cronbach’s α of the seven SoC subscales in our sample (n=167)

To answer research question 1, we constructed average SoC-profiles with the data of all three years (including pre and post test in 2015). Figure 1 shows that the subscale means of the 2013 questionnaire are considerably different to all other years. This observation is supported by t-tests for every combination of subscales except for stage III of 2014 (p=.057) and 2015’s post test stage 0 (p=.176). The graph shape of 2013 belongs to an interested nonuser (George et al., 2008).

The differences of stages I, II and IV in 2014 compared to the pre test from 2015 and stage 0 of the post test from 2015 are above the significance threshold of p=.05. When comparing the pre and post test of 2015, stages 0 and IV are the only stages without a significant difference (p>0.35). Therefore it is unsurprising that those three measurements’ graph shapes only deviate slightly and can be interpreted as cooperators (Bitan-Friedlander et al., 2004). Attendants of those three years have got a split attention focus in self (peak at stage I informational) and impact concerns (peak at stage IV collaboration) regarding the implementation of statistics and the GC at school and show an M-shaped profile.

![Figure 1: Subscale means, arranged by subscales and survey](image-url)
This very clear difference can be related to different kinds of innovations (related to our project in 2013 – state based innovations in 2014/2015). We have to be aware that, apart from the average values, there is a lot of variability in the individual SoCs. We will discuss this below.

With regard to research questions 2 and 3 we do not see a substantial difference between 2014 and 2015 (although one might have expected this because the teachers had been aware of the state innovations for one year longer.) On the level of the average profile we can detect a systematic difference, which however is not statistically significant.

Related to research questions 2 and 3 a cluster analysis was employed to identify different types of participants and how often they occur at the various points of measurement. We decided to put all data (n = 167) together for identifying clusters. This is useful when the distribution into the clusters is to be compared for the different measurement points. At first six clusters were identified by our cluster method. Upon closer inspection of these groups, twice we found two clusters that were identical in their graph shape but shifted by one scale point. So we decided to combine those two similar clusters into bigger group. Finally four clusters remained, which had been identified in a very similar way before in other studies (see George et al. (2008) and Pant et al. (2008b) for a description of the profiles). These clusters can be labeled *unconcerned innovation user* (n=4), *typical nonusers* (n=29), *information seeking cooperator* (n=59) and *self-orientated cooperator* (n=93) after their characteristic graph shapes (see Figure 2).

![Figure 2: Subscale means profile by cluster](image)

![Figure 3: Distribution of persons at one measurement into clusters](image)
It is noteworthy that all four people belonging to the unconcerned innovation user cluster were found in 2013, see Figure 3. Also, the majority of the typical nonuser group attended the course in 2013. As mentioned before, 2013 differed from the other years. This impression continues for the distribution of persons into clusters. The differences to the others cohorts are below the significance threshold (p<0.001). Participants in 2014 and 2015 are often assigned to one of the two cooperator clusters. The 2014 distribution shows an insignificant difference (p>0.444) to both tests from 2015. The pre and post tests from 2015 show a slight deviation of the cluster distribution (p=0.057). In 2015 there is a migration of 14 persons into different clusters. 71.42% of those (n=10) shift from the information seeking cooperator cluster to the higher self-orientated cooperator cluster. Another person switched from typical nonuser to information seeking cooperator. Only three moved to a “lower” cluster.

Discussion and remarks

According to the study we can distinguish two main groups in the 2014 and 2015 course, the information seeking cooperator and the self-orientated cooperator. One of the “effects” of the course is the shift from the first to the second. We have to study in more detail, in which respect these two groups differ and what factors influence to which cluster teachers are assigned. The design of the course will take this into account by addressing specific course elements to the two different groups. As mentioned before, our further goal is to combine the SoC profiles with other parts of our study. Doing so will allow us to validate our results, gain new insights and recognize a correlation between two aspects. In 2016/2017 we are implementing a fourth course. We also intend to expand our study by adding questions to the “level of use” (Hall, Loucks, Rutherford, & Newlove, 1975) and conducting another surveys six months after the course’s end in order to measure the long term effects. We also intend to interview the participants to get an insight into their lessons and teaching style, so that we can create a link between their SoC profiles and teaching practice.

Acknowledgements

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