Running head: ATTITUDE-BEHAVIOUR RELATIONS IN TEACHING

Attitude-behaviour relations in teaching natural science

Results from a longitudinal study using the theory of planned behaviour

Henrik Andersen^{1,1}, Jochen Mayerl¹, Gabriele Hornung² und Christoph Thyssen³

¹ Empirical Social Research, Chemnitz University of Technology

² Chemistry Didactics, Technische Universität Kaiserslautern

³ Biology Didactics, Technische Universität Kaiserslautern

¹ Chemnitz University of Technology, Thüringer Weg 9, 09126 Chemnitz, Germany.
E-mail address: henrik.andersen@soziologie.tu-chemnitz.de.

Abstract

This study looks at factors influencing pre-service teachers' use of experiments in the classroom. The study is a panel survey of high school -level biology and chemistry pre-service teachers in Rhineland Palatinate, Germany from 2013-2017. The study applies the Theory of Planned Behaviour and looks at attitudes, norms, behavioural control, and intentions as the main explanatory variables. The analyses show that attitudes, subjective norms and behavioural controls play important roles in determining the use of experiments. For biology teachers, attitudes are the strongest predictors of the use of experiments. For chemistry teachers, behavioural control is the strongest predictor.

Keywords: natural science teaching, behaviour, theory of planned behaviour, experiments, inquiry-based teaching

Funding: This work was supported by the Ministry of Education and Ministry of Science, Further Education and Culture, Federal State of Rhineland Palatinate (formerly Ministry of Education, Science, Further Education and Culture).

1. Introduction²

Lessons in natural science education follow the goals of conveying a) subject knowledge, b) the principles of scientific inquiry (the 'nature of science') and/or c) scientific methods (Bruckermann, Arnold, Kremer & Schlüter, 2017). Inquiry-based teaching encompasses the concept of allowing pupils to participate practically in lessons, allowing them to discover relations and causal effects on their own. Inquiry-based teaching gives pupils the chance to learn about scientific methods first-hand while principles of scientific inquiry and subject knowledge are conveyed more indirectly. Inquiry-based teaching is thereby seen as a way to combine all

² Abbreviations: SEM = structural equation modelling; TPB = Theory of planned behaviour

three goals (Millar, 2004). As such, it has become an influential concept in educational science and didactics. Indeed, most would agree inquiry-based teaching and a more active involvement of the pupils is generally preferable to rattling-off subject knowledge for the pupils to memorize. Recent reforms of German teachers' education programs have placed on increased importance on didactics and educational sciences with the goal of producing teachers that are not just well versed in the subject knowledge, but who are also able to more effectively convey the material to the pupils (Sedlmeier, Jänchen, Rauh, Langer & Partschefeld, 2010).

So, there are strong arguments to be made for the use of more inquiry-based styles of teaching and this line of reasoning has informed concrete political steps in the development of German teachers' education programs. If it can be said then that, from a normative perspective, teachers *should* incorporate more inquiry-based teaching into their lessons, then the task remains to convince them to actually do so. Reform steps at the system level can create more favourable conditions but ultimately teachers' behaviour cannot be deterministically changed from the topdown.

This study attempts to explain teachers' behaviour with regards to inquiry-based teaching methods using the example of experiments in the natural science classroom. In the natural sciences, the experiment is an obvious example of an inquiry-based teaching approach. By mixing chemicals or observing plant growth in an experimental design, pupils gain an understanding of scientific methods and devices as the subject-matter and the general principles of scientific inquiry are conveyed. Using the TPB (Fishbein & Ajzen, 2010), currently one of the most prominent theoretical frameworks in social sciences, we look specifically at attitudes, norms, behavioural control and their underlying beliefs to explain, on an individual-level, why teachers decide to experiment in their lessons.

The analysis is quasi-experimental in comparing pre-service teachers of the former "state exam"-system to those of the new bachelor- and master-programs that have an increased focus

on didactics and education sciences. We sample pre-service biology and chemistry teachers in Rhineland-Palatinate in the second, practical phase of their teachers' education programs. In doing so, we observe future teachers in their 'blank slate' form, before any of them have had the chance to gain practical experience (besides short internships) as a teacher. We thus attempt to isolate the effect of teachers' education university programs. Our study provides explanations for teachers' behaviour and helps generate recommendations for teachers' education programs in order to increase the use of experiments and promote inquiry-based teaching. We test the causality of the model using SEM in a longitudinal design: participating pre-service teachers were surveyed up to three times at intervals of roughly six months regarding their beliefs, attitudes, subjective norms, perceived behavioural controls, behavioural intentions and actual behaviour. We lag the dependent variable, the actual reported behaviour, by six months in order to be sure of the causal direction. In doing so, we look specifically at causal mechanisms responsible for influencing behaviour with regards to experiments and provide a more in-depth look at how exactly teachers' education can influence teachers' behaviour.

In the following section, the central research questions will be formulated. After that, the theoretical approach will be introduced. Here, we will discuss the TPB and how it will help causally explain pre-service teachers' behaviour with regards to experiments. In the Method and Data section, the sample and data collection will be outlined. The empirical analysis presents the results separately for pre-service teachers with the subjects' biology and chemistry and will begin with a descriptive look at the main variables of interest. Then, the results of the structural equation models will be presented. To conclude the empirical analysis, we will examine the underlying beliefs in a SEM framework. In the final section, the results will be discussed in the context of their relevance to the discussion of how to improve natural science lessons in the subjects' biology and chemistry.

2. State of the research

This study applies the TPB (Fishbein & Ajzen 2010), currently one of the most commonly applied theoretical approaches for looking at attitude and behavioural relations, to explain teachers' behaviour with regards to experiments. As will be shown, it provides a good basis for analyzing lesson-related behaviour and may lend itself to analyzing various other teachers' behaviours.

There is fairly large and growing body of research concerning the explanation and prediction of teachers' behaviour. To this end, the TPB has been applied in a wide variety of contexts. Some studies, such as those of MacFarlane and Woolfson (2013), Mulholland and Cumming (2016), Sharma and Jacobs (2016) look at teachers' behaviour with regards to the inclusion of disabled pupils, for example. Others, such as Stanec (2009) look at the use of fitness tests, while Wang (2010) has examined so-called Teaching Games for Understanding (TGfU) in physical education. Underwood (2012) investigated Japanese high school teachers' behaviour with regards to teaching English. Sadaf, Newby and Ertmer (2012) and Yusop (2015) look at teachers' use of Web 2.0 technologies.

A considerable amount of work has focused specifically on the behavioural control aspect of the TPB, referring either explicitly to the theory or under the heading of 'self-efficacy' (Bleicher, 2010; Carleton, Fitch & Krockover, 2008; Cox & Carpenter, 1989). A lot of the studies have looked at teachers' self-efficacy beliefs in terms of the inclusion of pupils with disabilities (Sharma & Sokal, 2015; Savolainen, Engelbrecht, Nel & Malinen, 2011). In other words, what perceived personal or institutional hurdles hinder the inclusion of pupils with disabilities?

Kilic, Emsen and Soran (2011) examined the use of experiments by teachers within the TPB as a theoretical framework. Their sample consisted of 157 pre-service teachers at Ankara Hacettepe University in Turkey in the subjects of biology, elementary science, physics and

chemistry. They found that attitudinal, normative and control beliefs strongly influenced attitudes, subjective norms and perceived behaviour controls, respectively. Further, they found attitudes have a strong influence on behavioural intentions. Perceived behavioural control and subjective norms have moderately strong effects. However, their study is limited by several factors. For one, their study is cross-sectional in nature and their model does not include any measures of actual behaviour; it is truncated at intentions. Even if they had included a measure of behaviour, it is likely the reports on behaviour would be influenced by the respondents' reported intentions and, thus, the validity of the measure would be suspect. Furthermore, they do not estimate separate models for the different subjects (which would likely have not been possible with the small sample size and even smaller sub-groups).

The present study looks at teachers' behaviour with regards to experiments that covers the entire hypothesized model of the TPB. Our longitudinal design allows us to be more confident in the casual direction of the relations. The sample size is sufficient to estimate separate statistical models for biology and chemistry pre-service teachers and examine difference between the subgroups. Furthermore, we surveyed every cohort of pre-service teachers at all the nine different teaching colleges in Rhineland-Palatinate from 2012-2015. In doing so, we were able to conduct a quasi-experiment by surveying the last cohorts of the old 'state-exam' model and comparing them with the new 'bachelor-master' pre-service teachers.

3. Research question

The central research question of this study is straightforward: why (or why not) do natural science teachers incorporate experiments into their lessons? To this end, we will apply the TPB and attempt to statistically explain actual reported behaviour with regards to experiments. The application of the TPB in explaining teachers' behaviour will be of a confirmatory nature. In a second, more exploratory step, we will furthermore investigate underlying beliefs that indirectly influence the behaviour. While it is true that underlying beliefs are further removed from

behaviour in the causal chain of explanation, they are of essential practical importance for generating recommendations for promoting the use of experiments.

A number of secondary research questions will be pursued as well. Firstly, do causal explanations of teachers' behaviour differ between the subjects of biology and chemistry? If so, of what practical relevance is the knowledge of these differences for teachers' education programs? Secondly, based on the quasi-experimental nature of the study, we are also able to explore whether pre-service teachers of the former "state-exam" model differ from those of the new "bachelor-master" programs of study. As mentioned earlier, the introduction of the new bachelor-master programs also brought with it an increased focus on didactics and educational sciences. How has this structural reform affected either the prevalence experiments or causal explanations for their use?

4. Theoretical approach

The TPB is one of the most widely used theories in the area of attitude-behaviour research. One of the main benefits of the theory is the possibility for decomposing causal effects in multiple mediator models within the overall causal model (Ajzen, 1985, 1991, 2005; Ajzen & Fishbein, 2000; Fishbein & Ajzen, 2010). It describes how attitudes towards a behaviour, as well as subjective norms and perceived behavioural controls or hindrances all exert an influence on actual behaviour although they are mediated by behavioural intentions. Attitudes towards behaviour, subjective norms and perceived behavioural controls are themselves the result of cost-benefit considerations, evaluations and expectations about specific attributes related to the attitude object or behaviour, referred to as beliefs (see Mayerl 2009 for an in-depth critical discussion of the TPB). Figure 1 shows the theorized causal model of the TPB.

Figure 1: visual representation of the TPB

Ajzen, 2005: 135

The decision to conduct an experiment in the biology or chemistry classroom is the result of all of these factors. Beliefs describe various, often subconscious, causal assumptions related to the attitude object. Behavioural attitudes, subjective norms and perceived behavioural controls result from the sum total of behavioural, normative and control beliefs, respectively. People can simultaneously hold both positively- and negatively-connotated beliefs. The overall tendency of the attitude, from overwhelmingly positive to overwhelming negative, is based on the sum of the sometimes competing views.

The behavioural belief that experiments lead to a better understanding of the subject matter will likely influence a more positive attitude towards experiments, for example. Conversely, the belief that experiments are time-consuming will negatively impact the attitude. Normative beliefs involve assumptions regarding what is socially expected of oneself. A pre-service teacher that believes pupils expect them to use experiments will feel pressure to actually do this (subjective norm). Control beliefs are related to ideas about supporting and hindering factors. For example, the belief that one does not have a strong enough grasp on the subject matter is a

behavioural control factor that may dissuade one from wanting to attempt to incorporate experiments into lessons.

Behavioural intentions are influenced in part by attitudes, norms and behavioural controls. If a pre-service teacher has, overall, a mainly positive attitude towards experiments, if they feel it is expected of them by those whose opinions mean a lot to them, and if they feel they are in control and capable of doing so, they will likely express the intention to perform the behaviour and incorporate experiments into lessons. However, ultimately the model describes a stochastic relationship and while intention influences behaviour, it does not determine it, statistically speaking, as other confounding factors may also play a role in influencing behaviour. Such possible confounders will be addressed further in the empirical analysis. Furthermore, the TPB stipulates that behaviour can be directly influenced by behavioural control in the way that it can present a type of knock-out criteria: while someone may have positive attitude, and feel pressure by others to conduct experiments, a lack of behavioural control can negate intentions and ultimately lead to the behaviour not being performed.

5. Method and data

The data was collected in the research project EVA³PLUS in the form of a computer-assisted self-interview (CASI) survey of all biology and chemistry pre-service teachers in the second phase of their education (in Germany this second phase is referred to as “Referendariat”) in Rhineland-Palatinate from the winter semester 2013 to the winter semester 2017.^{3,4} The research design is a longitudinal panel study with participants taking part in intervals of roughly

³ EVA³PLUS was funded by the state Ministry of Education, Science, Further Education and Culture Rhineland-Palatinate (now Ministry of Education and Ministry of Science, Further Education and Culture).

⁴ Although we conducted the surveys at all teachers’ training colleges in Rhineland-Palatinate to observe population data, we had to deal with unit non-response. The exact response rate is not able to be determined without records of pre-service teachers in Rhineland-Palatinate including data on drop-outs in the second phase of education. In total, 47 surveys of the various educational institutions were successfully carried out. Illness and absentness for other reasons prevented some pre-service teachers from taking part although the longitudinal nature of the project meant we were often able to survey these people in at least one wave of data collection.

6 months for 3 waves of data collection. 631 individual surveys were carried out with 415 unique respondents. Pre-service teachers in Rhineland-Palatinate study two subjects. 335 respondents of this survey studied biology along with a second subject⁵ (not including chemistry), 151 studied chemistry along with a second subject (not including biology) and 145 respondents studied both biology and chemistry.

The TPB was operationalized to suit the research question by adapting indicators found in the literature on the didactic method of experimentation in biology and chemistry lessons (see for example Welzel et al, 1998; Weigelt & Grabinski, 1993).

The hypothesized model was operationalized using multiple-indicator latent structural equation measurement models. Table 1 gives an overview of the latent constructs and their indicators.

All constructs display good reliability (Cronbach's Alpha values > 0.7). In a confirmatory factor analysis, the models showed high levels of both convergent validity (all standardized factor loadings > 0.6) and discriminant validity (no cross-loadings) with a good model fit ($\chi^2 = 12.452$, $df = 11$, $p = 0.3307$, $RMSEA = 0.018$, C.I. (90%) = 0.000 –0.056, CFI = 1.000). The operationalization of all constructs displays high levels of construct validity meaning we can be confident in interpreting the results substantively.⁶

The TPB states that beliefs influence attitudes, norms and controls. Attitudes, norms and controls influence behavioural intentions and intentions ultimately influence actual behaviour. However, the TPB is not static and Ajzen states that past behaviour will influence future behaviour either by reinforcing or changing previously held beliefs, attitudes, perceived social norms and behavioural controls or by the generation of habits (Ajzen, 1991). For this reason, it

⁵ This could be mathematics, physics, geography, German, English or physical education.

⁶ The quality of the model can be evaluated using various "goodness of fit" indices. These indices report the extent to which the theoretical model fits the empirical data. For an acceptable model-fit, CFI ("Comparative Fit Index") should be >0.950, RMSEA ("Root Mean Square Error of Approximation") <0.050. Furthermore, the upper bound of the 90%-confidence interval of the RMSEA should not exceed 0.100 (see Kline 2011; Loehlin 2004; Urban & Mayerl 2014).

is important to establish the causal direction implied by the model. We do so by lagging the independent variables by at least one wave of data collection. For the independent variables, we took the first available data point. For the dependent variable behaviour, we took $t+1$ or, if that data was missing, $t+2$. By doing so we can be surer of the causal direction of the hypothesized structure. For the full hypothesized model, see Figure 3.

The following empirical analysis will attempt to explain pre-service teachers' behaviour with regards to experiments and will examine whether explanations differ between the subjects biology and chemistry. This type of analysis involves looking at linear relationships between predictors and outcomes: do increasingly positive attitudes towards experiments actually lead to an increase in the frequency with which they are used in lessons, for example, and how strong is this relationship? In comparative studies, however, we are sometimes not only interested in whether one group differs from the other in terms of the presence and strength of these relationships but also in differences in terms of base levels. Do chemistry and biology preservice teachers already differ with regards to their base levels on either predictor or outcome variables? To answer these questions, in the following section, we will first look at the univariate descriptive statistics.

6. Empirical analysis

6.1. Descriptive statistics and overall levels

The descriptive statistics presented in Table 1 indeed already reveal some interesting differences. Across the board, a strong link between the subject chemistry and experiments can be seen. Respondents with the subject chemistry have more positive attitudes towards experiments, feel more strongly that others expect them experiment in their lessons (social norm) and feel more in control of their ability to experiment (behavioural control). Thus, it is not surprising that they also express the intention to conduct experiments much more frequently (intention) than respondents with the subject biology and, ultimately, they actually do use

experiments in their lessons much more frequently (behaviour). The pre-service teachers surveyed with the subject chemistry replied, on average, that it was 'rather likely' that they would experiment every fifth lesson in the next six months (I1, chemistry) and that they intended to experiment around every 3th lesson (I2, chemistry). Biology teachers, on the other hand, replied, on average, that it was neither likely nor unlikely that they would experiment every 5th lesson in the next six months (I1, biology) and that they actually intended to only experiment every 5th to 6th lesson (I2, biology). In both cases, the actual reported behaviour was somewhat more infrequent than the average expressed intention. Chemistry pre-service teachers in the study had experimented between every 3rd to 4th lesson in the previous six months (B, chemistry) while those with the subject biology had only done so around every 5th to 6th lesson (B, biology).

So, although it seems quite clear that pre-service chemistry teachers use experiments much more often than their colleagues teaching biology, several important questions remain. First, the univariate statistics only hint at causal relationships. Multivariate statistical models allow us to examine partial effects after controlling for correlations between the independent variables (which would appear to be substantial) and other possible confounders. The SEM framework also makes it possible to examine multiple mediator models and gain a better understanding of the overall causal structure. Second, the crucial question as to *why* remains. Answering these questions will be the focus of the following empirical analysis.

The empirical analysis involves the estimation of structural equation models separately for biology and chemistry pre-service teachers. The hypothesized causal model can be seen in Figure 2. Models were estimated using Mplus 7.4 (Muthén & Muthén, 1998-2018). All following models were estimated with a weighted least squares means and variance adjusted (WLSMV) estimator which adjusts for the categorical nature of the indicators (Finney & DiStefano, 2006). Model fit indices can be found below the figure. Control variables are not

shown in Figure 2 but included in model: the respondent's subject combination (biology with chemistry vs. not in combination), university at which pre-service teachers took their exam (A, B, C vs. others), degree type (BA/MA vs. state exam), as well as variables for whether or not intention was asked before or after behaviour and whether the item order was randomized or not.

Table 1: Overview of model constructs and indicators

Construct	Indicators	Response scale	Mean (SD)		Reliability (α)	
			Bio.	Chem.	Bio.	Chem.
Attitude	A1: I find carrying out a lot of experiments to be generally negative. [R] [S1]	1: do not agree at all, 2: mostly do not agree, 3: somewhat do not agree, 4: neither/nor, 5: somewhat agree, 6: mostly agree, 7: agree fully and completely	5.35 (1.00)	5.55 (1.21)	0.767	0.772
	A2: I think it makes sense to carry out a lot of experiments in my lessons. [S1]	see above	5.42 (1.03)	5.77 (1.02)		
	A3: Overall, I find it isn't necessary to carry out a lot of experiments in my lessons. [R] [S1]	see above	5.63 (1.05)	6.11 (0.86)		
Norm	N1: The most important people to me would find it good if I were to carry out a lot of experiments in my lessons. [S1]	see above	4.74 (1.59)	5.20 (1.43)	0.862	0.882
	N2: Most people, whose opinion is important to me think I should experiment a lot in my lessons. [S1]	see above	4.45 (1.48)	5.01 (1.29)		
Control	C1: All in all, I find it really easy to carry out experiments in my lessons. [S1]	see above	3.62 (1.39)	4.71 (1.26)	0.715	0.780
	C2: I find I run into trouble when I want to carry out experiments in my lessons. [R] [S1]	see above	3.86 (1.55)	4.57 (1.51)		
Intention	I1: Please take a moment and think about the next 6 months of your biology/chemistry lessons: How likely is it that for each class you will carry out an experiment in at least every 5 th lesson? [S1]	1: extremely unlikely, 2: very unlikely, 3: rather unlikely, 4: neither/nor, 5: rather likely, 6: very likely, 7: extremely likely	3.75 (1.44)	4.52 (1.48)	0.858	0.809
	I2: And what do you intend to do in the next 6 th months of your biology/chemistry lessons? How often do you want to carry out experiments? [S1]	1: never, 2: less than every 19 th lesson, 3: every 10 th -19 th lesson, 4: every 7 th -9 th lesson, 5: every 5 th -6 th lesson, 6: almost every 4 th lesson, 7: every 4 th lesson, 8: every 3 rd lesson, 9: almost every 2 nd lesson, 10: every 2 nd lesson, 11: in about 3 of 4 lessons, 12: every lesson	4.97 (1.49)	7.68 (2.07)		
Behaviour	B: Please think about your biology lessons in the last 6 months: How often did you carry out experiments in your lessons? Please indicate the total amount in terms of both biology and chemistry lessons. [S2]	1: never, 2: less than every 19 th lesson, 3: every 10 th -19 th lesson, 4: every 7 th -9 th lesson, 5: every 5 th -6 th lesson, 6: almost every 4 th lesson, 7: every 4 th lesson, 8: every 3 rd lesson, 9: almost every 2 nd lesson, 10: every 2 nd lesson, 11: in about 3 of 4 lessons, 12: every lesson	4.59 (1.81)	7.63 (1.96)	-	-

[S1]: wave t, [S2]: wave t+1 or, if missing wave t+2, [R] variable recoded for data analysis, higher values indicate more positive attitudes, higher intention, more frequent behaviour etc.

6.2. Causal Models

Full structural models were tested separately for a) those who studied chemistry along with another subject and b) those who studied biology along with another subject. The following Figure 2 shows the hypothesized model. SEMs are typically illustrated using such path diagrams as the one shown here. Circles represent ‘latent’ factors representing the underlying theoretical construct and boxes represent the indicators at the measurement level. One-headed arrows imply a causal effect: $x \rightarrow y$ thus can be read as the hypothesized effect of “x on y”. SEMs can be broken up into two overarching components: the measurement model and the structural model. Measurement models specify the relationship between the latent theoretical concepts and the indicators used to measure them. Latent factors are seen as the cause of the scores on the indicators (i.e. Attitude $\rightarrow$ A1, A2, A3). The structural equations represent the causal relationships between model components, thus attitudes are seen as the cause of behavioural intentions, for example. Another important concept in SEM is the decomposition of observed variance in ‘explained’ and ‘unexplained’. The causal relationships suggested in the path diagram are calculated using multiple regression. Just as in typical regression analyses, what results is a separation of variance that can be statistically explained by the independent variable(s) and that which is not explained, the so-called ‘residual’ or ‘error’. Thus, for example, indicator A1 is modeled as the additive result of the underlying latent attitude and an unexplained residual. Residuals (or ‘disturbances’ if they are referring to the unexplained variance of a latent factor) are represented by the arrows with no origin. They encompass the effects of all other unobserved (and thus latent) influences (for an introduction to the concepts of SEM see Schumacker & Lomax, 2004; Loehlin, 2004; Kline, 2011; Urban & Mayerl, 2014). The variables shown at the bottom of the diagram have been chosen as controls, and in the case of ‘university education’, which represents whether the respondent was of the old ‘state-exam’

or new ‘bachelor-master’ program of study, we actually have a more concrete substantive interest in the effect.

To summarize, the model shows the latent factors for attitudes, subjective norm and behavioural control measured by three, two and two manifest indicators respectively. Behavioural intention is measured by two manifest indicators. The actual reported behaviour is measured by a single manifest indicator (refer again to Table 1). Behavioural intention is the result of the combined partial effects of attitudes, subjective norms and behavioural control, as well as the control variables for subject combination, the university at which one studied, the program of study (pre- or post-reform) and the survey method⁷, plus an unobserved error term. Behaviour is the result of behavioural intention, the control variables and the error term.

The two-headed arrow connecting the attitude-indicators A1 and A3 indicate a correlation between the residuals of these indicators (also referred to as ‘error covariance’). This means there is systematic variance common to A1 and A3 that is not accounted for by the latent construct. In this specific case, the indicators A1 and A3 are both negatively worded in contrast to the positive indicator A2. This is why A1 and A3 share systematic error variance.

Not shown are covariances specified between the so-called ‘exogenous’ variables, or those without any arrows pointing towards them (attitudes, subjective norms, behavioural control and the control variables) and between the control variables and the other three exogenous latent factors. Here, the resulting coefficients of the specified correlations (two-headed arrows) are interpreted in the same way that the causal effects (one-headed arrows). Specifying a correlation instead of a causal effect simply illustrates that we do not have any concrete hypotheses about the relationship and are primarily concerned with holding their effects constant.

⁷ These last two variables control for the influence of the randomized question orderings in the survey.

Again, effects are the result of multiple regressions in which the covariances between independent variables in an equation are first partialled out. This means the coefficients must be interpreted as marginal effects, holding the effects of all other influences constant.

Figure 2: Hypothesized model

Not shown: covariances between control variables and between control variables and attitudes, subjective norms and behavioural controls

The following Figure 3 shows the structural model results for respondents with chemistry along with another subject ($n = 192$). Model fit is good with $CFI = 0.995$ and $RMSEA = 0.039$.

For the empirical model results, the discussion of the measurement models in which normally the standardized factor loading scores of the indicators on the latent constructs is the focus, will be forgone. In each case, the measurements showed no serious cause for concern with standardized factor loadings ≥ 0.5 , in all but one case even ≥ 0.7 . When comparing effects

within models, the standardized effects will be shown. This makes it possible to compare effects of variables with different scaling directly. Results displayed in the path diagrams are also the standardized effects. Later, when the two models are compared with each other, the unstandardized effects will be displayed as the calculation of standardized coefficients are sensitive to the specific characteristics of individual models (see Urban & Mayerl, 2014). As a final note, only the significant ($p < 0.05$) coefficients will be discussed and shown in the figures. Due to the model complexity, it would not be possible to clearly show all the specified coefficients in the figures. Also, discussing each non-significant path would likely become tiresome for the reader.

The respondent's attitude towards experiments in Chemistry has a moderate, statistically significant effect (0.223, $p < 0.01$) on their intention to carry out experiments in lessons. Respondents with more positive attitudes towards experiments actually do express significantly stronger intentions to experiment. Behavioural control has an even larger effect (0.376, $p < 0.001$). This indicates that the subjective assessment of the respondents' ability to use experiments is an even stronger predictor of intention than the attitude. Subjective norms involving perceptions of what others expect of them has no significant effect on behavioural intentions. It is important to point out that this does not mean that pre-service teachers with the subject chemistry do not feel pressure from others to experiment – in fact, the subjective norm to do experiments is actually higher amongst the chemistry teachers than the biology ones (refer back to Table 1). Rather, although they perceive the subjective norm, it does not affect the behavioural intention to implement experiments in teaching Chemistry – it is the personal attitude and especially the behavioural control which do matter.

Respondents with both subjects chemistry and biology reported a significantly weaker intention to experiment (-0.168, $p < 0.05$). Thus, in the group of chemistry pre-service teachers, the

influence of the second subject of study being biology was enough to pull the intention significantly downward.

We furthermore observe several significant correlations between the control variables and the exogenous latent factors. One particular university, (University C) was associated with significantly more positive attitudes towards experiments as well as stronger subjective norms ($p < 0.01$).⁸ This is an interesting result and raises questions about whether we should interpret this to mean that this university ‘caused’ more positive attitudes and stronger subjective norms on average, or whether and to what extent a selection bias in the sense of preferences of specific students towards choosing to study at a specific university is at play. Also, interesting from a methodological standpoint, we observe a random question order in the survey had a significantly positive effect on latent attitudes.

The model is able to statistically explain 38% of the variance of the latent factor behavioural intention for Chemistry (this is a common explanation power for TPB, see for example Ajzen, 2005). Behavioural intention itself has a strong positive effect (0.468, $p < 0.001$) on the actual reported behaviour of the respondent at least half a year later. Furthermore, as postulated by the TPB, for respondents with the subject chemistry, behavioural control has a significant positive direct effect on the reported behaviour (0.221, $p < 0.05$). Around 43% of the variance of the variable behaviour can be statistically explained by the model, which again is quite usual for TPB.

Figure 3: SEM Model, Chemistry

⁸ Because the results here could be used in ways that they were not intended and generally to avoid sparking conflict in Rhineland Palatinate’s higher education political scene, we have anonymized the universities.

N = 192, standardized estimates, estimator: WLSMV, $\chi^2 = 80.057$, $df = 62$, $p\text{-value} = 0.0612$, RMSEA = 0.039 (90% C.I. = 0.000 – 0.062), CFI = 0.995, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, Not shown: non-significant effects and covariances of control variables.

For respondents with the subject biology, all three factors play a significant role in influencing behavioural intention: Both subjective norms and behavioural control have moderate significant positive effects of around 0.24 ($p < 0.001$) on behavioural intention. Attitudes towards experiments have a slightly stronger influence of 0.282 ($p < 0.001$).

This time, respondents with the subject biology from University C actually displayed a significantly lower intention to experiment than the other universities (-0.171 , $p < 0.05$). Refer back to the finding that, amongst the chemistry pre-service teachers, this same university was associated with more positive attitudes and stronger subjective norms which then themselves lead to higher intentions to experiment.

29% of the variance of the latent factor behavioural intention was statistically explained by the model. Behavioural intention has a strong significant effect on the actual reported behaviour at least half a year later (0.511, $p < 0.001$) and the model can statistically explain 32% of the variance of the variable behaviour. As opposed to respondents with the subject chemistry, there is no significant direct structural path going from behavioural control to behaviour.

Figure 4: SEM Model, Biology

$N = 312$, standardized estimates, estimator: WLSMV, $\chi^2 = 83.902$, $df = 63$, $p = 0.0404$, RMSEA = 0.033 (C.I. = 0.007 – 0.050), CFI = 0.995, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, not shown: covariances between control variables.

Thus, to sum up, there are three most striking differences between the subjects of Chemistry and Biology. Firstly, subjectively perceived social norms are an important predictor for Biology pre-service teachers as opposed to Chemistry pre-service teachers who are not concerned with the social pressure to do experiments. This may simply be the result of the difference between

these two subjects: Chemistry is always about experimental work, no matter what others think. On the contrary, Biology is not necessarily an experimentally orientated subject. Here, the social peer groups are important to strengthen the behavioural intention to actually implement experiments in teaching. Secondly, another interesting finding is that in the case of Chemistry, the strongest predictor of intentions is the perceived behavioural control to actually do experiments in school. Thirdly, behavioural control does even directly affect actual behavior for chemistry pre-service teachers. This is not the case for biology. Here, behavioural control affects behavior only indirect, mediated by the intention to do experiments. This additionally points out that behavioural control is indeed the most important factor to explain the implementation of experiments in the case of chemistry.

We now turn to the foundation of the three overall judgments ‘attitude’, ‘subjective norm’ and ‘behavioural control’ in order to identify which substantial beliefs may be the driving forces of hindering or facilitating the implementation of experiments in teaching natural sciences at school.

6.3. Salient Beliefs

Beliefs are, as Ajzen and Fishbein describe, subjective probabilities (Fishbein & Ajzen, 2010). Beliefs inform us about how the world works. Implicitly, they define assumed causal relationships and help individuals decide the probability that performing behaviour x will lead to outcome y. They are the foundation of the TPB and attitudes, subjective norms and behavioural control. More specifically, these three constructs are the result of the sum total of the multiple, sometimes conflicting beliefs held about a behavioural object. Attitudes are thus the spontaneous and mostly unconscious weighing of beliefs surrounding a behaviour object. So, after now having found that attitudes, subjective norms and behavioural control significantly effect actual behaviour with regards to experiments, the task becomes to investigate the underlying beliefs as the fundamental but indirect causes of behaviour. In doing

so, we identify (to apply a German saying) what screws can be turned; i.e. if positive attitudes lead to more experimenting, what can be done to ensure teachers develop positive attitudes?

Salient beliefs refer to the most relevant beliefs for the formulation of attitudes. Fishbein and Ajzen (2010) refer to them as “beliefs about the object that come readily to mind” (p. 98). They are the ones that play the biggest role in determining how people react to an attitudinal object. For our study, the relevant salient behavioural, normative and control-related beliefs were determined in a pre-test study conducted at our university with a total of $n = 77$ students of biology and/or chemistry. After having determined the salient beliefs, we included them in the main study for each of the respondents to address. The following section will look at salient beliefs as determinants of the following latent factors in the causal chain. We again estimate SEMs separately for biology and chemistry pre-service teachers. We look specifically at causal relationships between each of the salient beliefs on the corresponding latent factor. For each belief, we receive a regression coefficient for its effect on the construct. The control variables from the previous structural models were included here as well but not shown in the figures. Model fit indices can be found below the figures. In short, the model fit is good in both cases, thus the results can be interpreted substantially.

Figure 5: Determinants of attitudes, subjective norms and behavioural controls, Chemistry

N = 174, standardized estimates, estimator: WLSMV, $\chi^2 = 292.860$, df = 311, p-value = 0.7627, RMSEA = 0.000 (90% C.I. = 0.000-0.021), CFI = 1.000, *p < 0.05, **p < 0.01, ***p < 0.001. Controlled for: Subject combination (Biology and Chemistry (1) vs. not combined (0)), university (dummies A, B, C vs. others), degree (BA/MA (1) vs. State Exam (0)), question order (1/0) and item randomization (1/0), no significant effects of control variables.

For the respondents with the subject chemistry (see Figure 5), we observe that none of the salient behavioural beliefs generated in the pre-test had a significant effect on attitudes. This is due to the relatively small sample size and too-large standard errors. The beliefs that experiments “Make lessons appealing” (0.129, p < 0.1) and “Teach pupils about using devices in practice” (0.124, p < 0.1) were significant at the 10% level.

For subjective norms, the belief that “University instructors” expected the respondents to use experiments had a fairly strong positive effect (0.421, $p < 0.001$). The expectations of the pupils also had a slight but significant impact for chemistry pre-service teachers (0.163, $p < 0.05$). The expectations of other actors such as subject instructors, parents, school directors and colleagues did not put chemistry pre-service teachers under pressure to use experiments.

Several beliefs had moderate to strong significant effects on perceived behavioural control. The strongest predictor for behavioural beliefs was “Necessary knowledge lacking” (-0.503, $p < 0.001$); respondents in the group chemistry that felt they did not have a grasp on the subject matter felt much more restricted in the behaviour. “Long preparation times” was another factor that lead to respondents expressing doubts as to their capability to use experiments (-0.230, $p < 0.001$). Respondents that felt they had their “Own ideas for experiments” (0.214, $p < 0.001$) and that the given “Equipment and facilities” were sufficient (0.150, $p < 0.001$) felt more confident in their ability to use experiments.

Figure 6: Determinants of attitudes, subjective norms and behavioural controls, Biology

N = 283, standardized estimates, estimator: WLSMV, $\chi^2 = 333.405$, df = 311, p-value = 0.1829, RMSEA = 0.016 (90% C.I. = 0.000-0.028), CFI = 0.976, *p < 0.05, **p < 0.01, ***p < 0.001. Controlled for: Subject combination (Biology and Chemistry (1) vs. not combined (0)), university (dummies A, B, C vs. others), degree (BA/MA (1) vs. State Exam (0)), question order (1/0) and item randomization (1/0), no significant effects of control variables.

For pre-service teachers with the subject biology (see Figure 6), several behavioural beliefs were shown to significantly affect attitudes. Respondents that believed experiments “Teach pupils about using devices in practice” (0.290, p < 0.01), “Make lessons appealing” (0.232, p < 0.01) and “Combine theory and practice” (0.172, p < 0.05) had more positive attitudes.

Interestingly, the belief that experiments “Interest the pupils” actually lead to more negative attitudes towards using experiments (-0.222, p < 0.01). It seems that pre-service teachers who

want pupils to be highly interested in the subject doubt that doing experiments helps to stimulate this interest.

On the other hand, for the subject biology, respondents reported that the expectations of the pupils (0.153, $p < 0.05$) are the only ones that put them under pressure to use experiments. Those of the other groups had no significant effects on subjective norms.

Similar to the subject group chemistry, behavioural control for the biology pre-service teachers was influenced negatively by the belief that the “Necessary knowledge is lacking” (-0.530, $p < 0.001$). The beliefs that experiments entail a “Long preparation time” (-0.245, $p < 0.001$) also made them feel less in control. When the respondents felt they had their “Own ideas” (0.201, $p < 0.001$), the “Equipment and facilities” were suitable (0.164, $p < 0.01$), and the behaviour of the pupils was conducive (0.107, $p < 0.05$) they tended to feel more volitional control. On the other hand, the “Curriculum guidelines” actually seemed to impede biology pre-service teachers’ perceived ability to use experiments (-0.109, $p < 0.05$).

7. Summary of results and discussion

This study looked at causes for the use of classroom experiments by biology and chemistry preservice teachers. The structural models showed that TPB is able to explain 29-38% of the variance of behavioural intention with respect to applying experiments in the classroom, and 32-42% of the variance of actual behaviour (using experiments in the classroom). These results point to the applicability of the TPB in explaining behaviour in teaching natural science-related subjects.

The structural models showed furthermore in both groups that attitudes towards experiments do indeed influence the intention to carry out experiments in lessons. This was more so true for the

subject biology (unstandardized regression coefficient⁹ 0.449, $p < 0.01$, see appendix for the unstandardized results) than chemistry (0.401, $p < 0.01$).

Subjective norms play only a role for respondents with the subject biology (0.305, $p < 0.01$). For the subject chemistry, subjective norms have no significant effect on the intention to experiment.

In both groups, behavioural control influences to a large extent the intention to use experiments. This is particularly relevant for the group with the subject chemistry (0.450, $p < 0.001$ vs. bio: 0.274, $p < 0.01$). Most importantly, however, is the fact that stating the intention to use experiments actually lead to higher reports of experimentation upwards of six months later. In the group with chemistry, intention had an unstandardized effect of 0.783 ($p < 0.001$) and biology 0.745 ($p < 0.001$). Furthermore, while in the group biology behavioural control is mediated completely by intention, for chemistry we observe a significant unstandardized direct effect (0.442, $p < 0.05$) meaning intention only partially mediates the effect of behavioural control on reported behaviour. For the subject chemistry, even those expressing an intention to experiment can ultimately be hindered by a perceived lack of ability to do so.

In a second step, the relevant salient beliefs as the underlying factors were examined. It was shown that the attitudes of chemistry pre-service teachers towards experiments were not sufficiently explained by any of the salient beliefs generated in the pre-test. For this group, there may to be other, unidentified factors at work. However, the statistical power of this particular model was likely insufficient to rule out type 2 errors. For the group of biology pre-service teachers, the strongest predictor of positive attitudes was the beliefs that experiments taught students about the practical use of devices and that they made their lessons more appealing.

⁹ In order to compare across models, we must look at the unstandardized results. However, because the variables were scaled the same way in both groups, this is unproblematic.

If chemistry pre-service teachers felt their university instructors and pupils expected them to use experiments, they felt pressure to actually do so. For biology pre-service teachers, the expectations of the pupils alone were what put them under pressure to use experiments. The opinions of the other groups seemed to be rather irrelevant.

Finally, in both groups, the respondents' perceived ability to incorporate experiments into their lessons was most strongly influenced by their grasp on the subject matter. Other factors, such as the facilities available and the wealth of one's own ideas, also influence their confidence in their ability to use experiments.

The examination of the important salient beliefs provides the most direct implications for decisions and policy. In order to cultivate positive attitudes towards experiments amongst biology teachers, it may be wise to emphasize their usefulness in familiarizing pupils with scientific devices, for example. For both groups, pressure put on pre-service teachers by their subject instructors at the teaching colleges ("Fachleiter") will not likely lead to an increase in experiments because their expectations were not particularly relevant in the formation of an intention to do experiments in teaching. On the other hand, it may be wise to communicate or allow the pupils themselves to express their desire for more experiments because the opinions of the pupils do seem to matter. And, as for overcoming hurdles, it seems like the best way to ensure pre-service teachers feel confident in their ability to experiment is to ensure they have an excellent grasp on the subject matter. Making sure the necessary equipment is easily available and that the facilities are suitable is an obvious, and now empirically shown important prerequisite.

As for some of the more secondary findings, it was interesting that, in the group with the subject chemistry, those who had biology as well expressed a significantly lower intention to experiment than those with any other combination of second subjects. In the group biology, it can be observed that university C, on an institutional level, is itself responsible for respondents

expressing less intention to experiment. Here in order to sensibly evaluate the effect it would be necessary to look for substantive reasons within the university as to why this is the case. The fact itself that while controlling for all the other influences in the model one university still is capable of exerting a negative influence on the intention to experiment is striking¹⁰.

One major finding is the lack of any significant effects of the degree type (bachelor-master vs. state exam) on either intention or behaviour as well as the antecedent attitudes, norms or controls (which were modelled as covariates rather than structural effects, the results of which can, however, be interpreted the same). The results show that although attitudes, norms and controls play varying roles in determining behaviour in the two subject groups, bachelor-master students do *not* differ from those of the old state exam model. While the decision to carry out experiments is influenced by one's confidence in their own subject-related education (see the strong significant effect of the salient belief "Necessary knowledge is lacking"), this itself is not influenced by whether or not one studied before or after the reform. The only indication we could find in contrast to this was a nearly marginally significant ($p = 0.134$) correlation in the group chemistry between degree type with behavioural control of -0.108 indicating those who studied bachelor-master programs may feel slightly less well equipped to carry out experiments. This confirms previous results of this research team in which we showed that while bachelor-master-degree pre-service teachers reported feeling significantly better prepared for teaching in terms of subject didactics and educational sciences, they differed almost not at all from state exam pre-service teachers in terms of their subject-related educations (Hornung et al. 2015, Thyssen et al. 2016).

¹⁰ A look at the covariances was also not able to elucidate this any further. There was a significant negative covariance with the variable for degree type indicating a larger proportion of the respondents of this university were of the older state exam model. However, as can be seen in the model diagrams above, both intention and behaviour do not seem to be influenced by degree type.

The increased emphasis in the new study programs on didactics and educational sciences were feared to lead to a neglect of the subjects themselves leading to cohorts of teachers first, scientists second. This, however, does not seem to be the case. The reform of teachers' education programs in Germany, at least in Rhineland-Palatinate, is not just a net improvement but rather an absolute one as there seem to be no deficits but only benefits arising from it.

This study is one of the first and likely the most comprehensive to empirically investigate teachers' behaviour with regards to experiments in the natural science classroom. It was shown that the TPB is a useful theoretical framework for this and other similar investigations. In a longitudinal design, we examined and compared the causes for biology and chemistry preservice teachers' use of experiments as well as the underlying beliefs and provided insight on ways of achieving the normative goal of increasing the use of experiments in the experimental natural science subjects. Future work may focus on replicating these results for samples in other geographic locations as well as for other natural science subjects such as physics.

Literature

- Ajzen, I. (1985): From intentions to actions: A theory of planned-behavior. In J. Kuhl, & J. Beckmann (Eds.), *Action-control: From cognition to behavior* (pp. 11-39). Heidelberg: Springer.
- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50, 179-211.
- Ajzen, I. (2005): *Attitudes, personality and behavior*. (2nd ed.). Maidenhead: Open University Press.
- Ajzen, I., & Fishbein, M. (2000): Attitudes and the attitude-behavior relation: Reasoned and automatic processes. In W. Stroebe, & V. Hewstone (Eds.), *European Review of Social Psychology* (pp. 1-33). New York et al: John Wiley & Sons.
- Bleicher, R.E.. (2010). Revisiting the STEBI-B: Measuring Self-Efficacy in Preservice Elementary Teachers. *School Science and Mathematics*, 104(8), 383-391. DOI: 10.1111/j.1949-8594.2004.tb18004.x.
- Bruckermann, T., Arnold, J., Kremer, K., & Schlüter, K. (2017). Forschendes Lernen in der Biologie. In T. Bruckermann, & K. Schlüter (Eds.), *Forschendes Lernen im Experimentalpraktikum Biologie* (pp. 11-26). Springer Verlag.
- Carleton, L.E., Fitch, J.C., & Krockover, G.H. (2008). An in-service teacher education program's effect on teacher efficacy and attitudes. *The Educational Forum*, 72(1), 46 – 62. DOI: 10.1080/00131720701603628.
- Cox, C.A., & Carpenter, J.R. (1989). Improving attitudes toward teaching science and reducing science anxiety through increasing confidence in science ability inservice elementary school teachers. *Journal of Elementary Science Education*, 1(2), 14-34. DOI: 10.1007/bf03173020.

- Finney, S., & DiStefano, C. (2006). Non-normal and categorical data in structural equation modeling. In G. Hancock, & R. Mueller (Eds.), *A Second Course in Structural Equation Modeling* (pp. 269-314). Greenwich: Information Age Publishing.
- Fishbein, M., & Ajzen, I. (2010). *Predicting and changing behavior: The reasoned action approach*. New York: Psychology Press.
- Hornung, G., Mayerl, J. & Thyssen, C. (2015): Evaluation der phasenübergreifenden Lehrerausbildung. Eine Längsschnittstudie zu Einstellungen und Verhalten von Referendaren. S. 43-45 in: Bernholt, S., (Hrsg.): Heterogenität und Diversität - Vielfalt der Voraussetzungen im naturwissenschaftlichen Unterricht. Proceedings der GDGP-Jahrestagung 2014. Kiel: IPN.
- Kilic, D., Emsen, P., & Soran, H. (2011). Behavioral intention towards laboratory applications in science teaching. *Procedia Social and Behavioral Sciences*, 28(2011), 416-420.
- Kline, R. (2011). Principles and practice of structural equation modeling. (3rd ed.). New York, London: The Guilford Press.
- Loehlin, J. (2004). *Latent variable models: An introduction to factor, path, and structural equation analysis*. Mahwah, New Jersey: Lawrence Erlbaum Associates.
- MacFarlane, K., & Woolfson, L.M. (2013). Teacher attitudes and behavior toward the inclusion of children with social, emotional and behavioral difficulties in mainstream schools: An application of the theory of planned behavior. *Teaching and Teacher Education*, 29, 46-52. DOI: 10.1016/j.tate.2012.08.006
- Mayerl, J., 2009: Kognitive Grundlagen sozialen Verhaltens. Framing, Einstellungen und Rationalität. Wiesbaden: VS Verlag. [Cognitive Foundations of Social Behaviour. Framing, Attitudes, and Rationality]

- Millar, R. (2004, October). The role of practical work in the teaching and learning of science. Washington, DC: *Committee High School Science Laboratories: Role and Vision, National Academy of Sciences*, 1-24.
- Mulholland, S., & Cumming, T.M. (2016). Investigation teacher attitudes of disability using a non-traditional theoretical framework of attitude. *International Journal of Educational Research*, 80, 93-100. DOI: 10.1016/j.ijer.2016.10.001.
- Muthén, L.; Muthén, B. (1998-2018). Mplus User's Guide. Sixth Edition. Los Angeles: Muthén and Muthén.
- Sadaf, A., Newby, T., & Ertmer, P. (2012). Exploring pre-service teachers' beliefs about using Web 2.0 technologies in K-12 classroom. *Computers and Education*, 59, 937-945.
- Savolainen, H., Engelbrecht, P., Nel, M., & Malinen, O.-P. (2011). Understanding teachers' attitudes and self-efficacy in inclusive education: Implications for pre-service and inservice teacher education. *European Journal of Special Needs Education*, 27(1), 51-68.
DOI: 10.1080/08856257.2011.613603.
- Schumacker, R., & Lomax, R. (2004). *A Beginner's Guide to Structural Equation Modeling*. (2nd ed.). Mahwah, New Jersey: Lawrence Erlbaum Associates.
- Sedlmeier, P., Jänchen, A., Rauh, N., Langer, S., & Partschefeld, I. (2010). Bachelor und Master – Alles nur ein Desaster? Was Lehrende in der Psychologie von der Umstellung der Studiengänge halten. *Beiträge zur Hochschulforschung*, 2010(2), 56-75.
- Sharma, U., & Sokal, L. (2015). The impact of a teacher education course on pre-service teachers' beliefs about inclusion: An international comparison. *Journal of Research in Special Educational Needs*, 15(4), 276-284. DOI: 10.1111/1471-3802.12043.

- Sharma, U. & Jacobs, K. (2016). Predicting in-service educators' intentions to teach in inclusive classrooms in India and Australia. *Teaching and Teacher Education*, 55, 13-23. DOI: 10.1016/j.tate.2015.12.004.
- Stanec, S. (2009). The theory of planned behavior: predicting teachers' intentions and behavior during fitness testing. *Journal of Teaching in Physical Education*, 28, 255-271. DOI: 10.1123/jtpe.28.3.255.
- Thyssen, C., Hornung, G. & Mayerl, J. (2016): Beeinflusst universitäre Ausbildung über Einstellung, Normen und Verhaltenskontrolle das Experimentieren im Biologie-Unterricht? S. 207-228. In: Gebhard, Hammann (Hrsg.): *Lehr- und Lernforschung in der Biologiedidaktik*. Innsbruck: Studienverlag.
- Underwood, P. (2012). Teacher beliefs and intentions regarding the instruction of English grammar under national curriculum reforms: A theory of Planned Behaviour perspective. *Teaching and Teacher Education*, 28(6), 911-925.
- Urban, D.; Mayerl, J. (2014). *Strukturgleichungsmodellierung. Ein Ratgeber für die Praxis*. Wiesbaden: Springer VS.
- Wang, C.L. & Ha, A. (2010). Pre-service teachers' perception of Teaching Games for Understanding: A Hong Kong perspective. *European Physical Education Review*, 15(3), 407-429. DOI: 10.1177/1356336X09364724.
- Weigelt, C., & Grabinski, E. (1993). VDBiol-Schulumfrage zum Thema Biologieunterricht: Pro Biologie: Wie läßt sich die Leistungsfähigkeit des Biologieunterrichts verbessern? [VDBiol-School Survey on the topic of biology lessons: How can we improve the effectiveness of biology lessons?].
- Welzel, M., Haller, K., Bandera, M., Hammelev, D., Koumaras, P., Niedderer, H., Paulsen, A., Robinault, K., & Aufschnaiter, S.v. (1998). Ziele, die Lehrende mit dem

Experimentieren in der naturwissenschaftlichen Ausbildung verbinden. Ergebnisse einer europäischen Umfrage [Goals that teachers associate with experiments in nature science teachers' education]. *Zeitschrift für Didaktik der Naturwissenschaften*, 4(1), 29-44.

Yusop, F. (2015). A dataset of factors that influence preservice teachers' intentions to use web 2.0 technologies in future teaching practices. *British Journal of Educational Technology*, 46, 1075-1080.

Appendix

Appendix Table 1: Measurement models

		Chemistry			Biology		
		Est. (Std.)	Std. err.	p	Est. (Std.)	Std. err.	p
ATT by	A2	1.000 (0.672)	0.000	999.000	1.000 (0.734)	0.000	999.000
	A3	1.263 (0.849)	0.181	0.000	1.114 (0.817)	0.057	0.000
	A4	1.277 (0.858)	0.099	0.000	1.204 (0.883)	0.062	0.000
NOR by	N1	1.000 (0.851)	0.000	999.000	1.000 (0.925)	0.000	999.000
	N2	1.092 (0.929)	0.116	0.000	0.927 (0.857)	0.065	0.000
CON by	C1	1.000 (1.006 ¹¹)	0.000	999.000	1.000 (1.042 ¹²)	0.000	999.000
	C2	0.713 (0.717)	0.119	0.000	0.644 (0.671)	0.100	0.000
INT by	I1	1.000 (0.840)	0.000	999.000	1.000 (0.825)	0.000	999.000
	I2	1.467 (0.891)	0.145	0.000	0.979 (0.773)	0.116	0.000

ATT=Attitude, NOR=Norm, CON=Control, INT=Intention, BEH=Behaviour

¹¹ The standardized factor loading for item C1 of greater than 1.0 resulted from an error variance of nearly zero. Manually constraining the error variance to something very small (0.001 for example) solved this problem but had no impact on the model results. 1.006 and 1.042, when rounded, can be still be interpreted as an explained variance of 1.0 by the latent factor Control.

¹² See footnote above.

Appendix Table 2: Structural paths

		Chemistry			Biology		
		Est. (Std.)	Std. err.	p	Est. (Std.)	Std. err.	p
INT on	ATT	0.401 (0.223)	0.153	0.009	0.449 (0.282)	0.148	0.002
	NOR	0.186 (0.131)	0.121	0.123	0.305 (0.241)	0.101	0.003
	CON	0.450 (0.376)	0.118	0.000	0.274 (0.244)	0.084	0.001
	COM	-0.401 (-0.168)	0.153	0.009	-0.431 (-0.166)	0.173	0.013
	DEG	-0.176 (-0.071)	0.207	0.397	-0.105 (-0.042)	0.164	0.523
	POS	0.129 (0.044)	0.248	0.602	-0.283 (-0.107)	0.175	0.106
	RAN	0.380 (0.157)	0.205	0.064	-0.162 (-0.069)	0.166	0.329
	UNI A	-0.292 (-0.114)	0.295	0.321	0.209 (0.078)	0.229	0.360
	UNI B	-0.182 (-0.061)	0.325	0.576	0.263 (0.102)	0.256	0.304
	UNI C	-0.194 (-0.073)	0.248	0.435	0.469 (0.171)	0.233	0.044
BEH on	INT	0.783 (0.468)	0.207	0.000	0.745 (0.511)	0.127	0.000
	CON	0.442 (0.221)	0.210	0.035	-0.051 (-0.031)	0.157	0.743
	COM	-0.349 (-0.086)	0.465	0.452	0.200 (0.053)	0.292	0.494
	DEG	-0.778 (-0.187)	0.526	0.139	-0.109 (-0.030)	0.296	0.714
	POS	0.371 (0.075)	0.660	0.139	0.593 (0.154)	0.314	0.059
	RAN	-0.436 (-0.108)	0.572	0.445	0.323 (0.095)	0.389	0.407
	UNI A	1.559 (0.364)	1.031	0.131	-0.416 (-0.107)	0.400	0.299
	UNI B	0.857 (0.173)	1.154	0.458	0.035 (0.009)	0.541	0.948
	UNI C	0.995 (0.225)	0.942	0.291	0.481 (0.120)	0.410	0.241

ATT=Attitude, NOR=Norm, CON=Control, INT=Intention, BEH=Behaviour,
 COM=Combination (Biology and Chemistry vs. not combined), DEG=Degree type (BA/MA
 vs. State Exam, POS=Position in Questionnaire, RAN=Randomized item order

Appendix Table 3: Covariances

		Chemistry			Biology		
		Est. (Std.)	Std. err.	p	Est. (Std.)	Std. err.	p
ATT with	NOR	0.268 (0.468)	0.054	0.000	0.343 (0.506)	0.040	0.000
	CON	0.140 (0.206)	0.053	0.008	0.178 (0.233)	0.045	0.000
	COM	0.014 (0.042)	0.026	0.591	0.092 (0.279)	0.020	0.000
	DEG	0.000 (0.001)	0.026	0.992	0.033 (0.097)	0.020	0.090
	POS	0.005 (0.017)	0.023	0.838	0.020 (0.061)	0.020	0.320
	RAN	0.067 (0.199)	0.025	0.009	0.026 (0.070)	0.022	0.253
	UNI A	-0.038 (-0.119)	0.023	0.106	0.017 (0.053)	0.020	0.387
	UNI B	-0.028 (-0.101)	0.021	0.182	-0.008 (-0.023)	0.019	0.697
	UNI C	0.071 (0.232)	0.028	0.010	-0.007 (-0.021)	0.019	0.721
NOR with	CON	0.183 (0.214)	0.061	0.003	0.129 (0.134)	0.053	0.014
	COM	-0.077 (-0.182)	0.033	0.018	0.045 (0.109)	0.024	0.062
	DEG	-0.034 (-0.083)	0.031	0.274	-0.004 (-0.009)	0.026	0.880
	POS	-0.024 (-0.068)	0.024	0.312	-0.010 (-0.025)	0.023	0.657
	RAN	0.008 (0.020)	0.030	0.781	0.003 (0.007)	0.027	0.910
	UNI A	-0.035 (-0.087)	0.031	0.267	0.016 (0.040)	0.025	0.519
	UNI B	-0.047 (-0.135)	0.028	0.091	-0.044 (-0.104)	0.026	0.092
	UNI C	0.089 (0.228)	0.030	0.003	0.004 (0.009)	0.024	0.880
	COM	0.043 (0.085)	0.038	0.262	0.170 (0.361)	0.024	0.000
CON with	DEG	-0.052 (-0.107)	0.035	0.138	0.030 (0.062)	0.027	0.261
	POS	0.020 (0.047)	0.032	0.542	0.016 (0.034)	0.026	0.547
	RAN	-0.045 (-0.090)	0.036	0.213	0.054 (0.104)	0.030	0.069
	UNI A	-0.029 (-0.061)	0.036	0.414	0.066 (0.145)	0.025	0.009
	UNI B	-0.025 (-0.061)	0.029	0.384	0.028 (0.059)	0.028	0.324
	UNI C	0.005 (0.011)	0.034	0.880	-0.024 (-0.054)	0.026	0.357

ATT=Attitude, NOR=Norm, CON=Control, INT=Intention, BEH=Behaviour, COM=Combination (Biology and Chemistry vs. not combined), DEG=Degree type (BA/MA vs. State Exam, POS=Position in Questionnaire, RAN=Randomized item order

Appendix Table 4: Covariances (control variables)

		Chemistry			Biology		
		Est. (Std.)	Std. err.	p	Est. (Std.)	Std. err.	p
COM with	DEG	0.041 (0.168)	0.017	0.015	0.008 (0.039)	0.012	0.501
	POS	0.042 (0.204)	0.014	0.003	0.010 (0.052)	0.011	0.343
	RAN	-0.014 (-0.057)	0.018	0.426	0.008 (0.037)	0.013	0.513
	UNI A	0.065 (0.275)	0.014	0.000	0.061 (0.311)	0.010	0.000
	UNI B	0.023 (0.115)	0.014	0.104	-0.009 (-0.043)	0.012	0.456
	UNI C	-0.049 (-0.213)	0.015	0.002	-0.014 (-0.070)	0.011	0.235
DEG with	POS	0.000 (0.000)	0.015	0.996	-0.010 (-0.049)	0.011	0.381
	RAN	-0.008 (-0.035)	0.018	0.635	0.016 (0.070)	0.013	0.215
	UNI A	0.044 (0.193)	0.016	0.007	-0.011 (-0.052)	0.011	0.349
	UNI B	0.079 (0.400)	0.004	0.000	0.085 (0.405)	0.012	0.000
	UNI C	-0.055 (-0.250)	0.014	0.000	-0.056 (-0.285)	0.010	0.000
POS with	RAN	-0.117 (-0.572)	0.006	0.000	-0.130 (-0.587)	0.004	0.000
	UNI A	0.023 (0.118)	0.013	0.086	0.013 (0.066)	0.011	0.227
	UNI B	-0.013 (-0.079)	0.013	0.321	-0.012 (-0.059)	0.012	0.311
	UNI C	-0.006 (-0.033)	0.014	0.653	-0.005 (-0.026)	0.011	0.657
RAN with	UNI A	0.000 (0.002)	0.017	0.978	0.000 (-0.001)	0.012	0.987
	UNI B	-0.015 (-0.073)	0.014	0.304	0.019 (0.086)	0.013	0.125
	UNI C	0.036 (0.159)	0.016	0.023	0.009 (0.043)	0.012	0.448
UNI A with	UNI B	-0.069 (-0.363)	0.007	0.000	-0.074 (-0.376)	0.003	0.000
	UNI C	-0.099 (-0.461)	0.002	0.000	-0.061 (-0.329)	0.008	0.000
UNI B with	UNI C	-0.062 (-0.336)	0.011	0.000	-0.069 (-0.356)	0.005	0.000

ATT=Attitude, NOR=Norm, CON=Control, INT=Intention, BEH=Behaviour,
 COM=Combination (Biology and Chemistry vs. not combined), DEG=Degree type (BA/MA
 vs. State Exam, POS=Position in Questionnaire, RAN=Randomized item order