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Advantages and Disadvantages of Modeling Beliefs by Single Item and Scale Models in the Context of the Theory of Planned Behavior

Benedikt Heuckmann *, Marcus Hammann and Roman Asshoff *

Centre for Biology Education, University of Münster, Schlossplatz 34, 48143 Münster, Germany; hammann.m@uni-muenster.de

* Correspondence: Benedikt.Heuckmann@uni-muenster.de (B.H.); Roman.Asshoff@uni-muenster.de (R.A.); Tel.: +49-251-83-39362 (B.H.)

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Abstract: Teachers' beliefs about science teaching vary greatly. To analyze the relationships between teachers' beliefs and other variables related to teaching and learning, researchers can use the following two options: single item belief models or belief scales. In this study, we compared both models in the context of teachers' beliefs regarding teaching about cancer. Although both models exhibited a good model fit, each approach had both advantages and disadvantages when we judged the modelling approaches in terms of fulfilling the requirements of common psychometric standards and adequately acknowledging the diversity of different beliefs. We discuss the predictive value of both models and their contribution to planning belief-based interventions for cancer education. We argue that researchers should combine the advantages of single item and scale models when analyzing the diversity of teachers' beliefs.

Keywords: theory of planned behavior; beliefs; MIMIC model; cancer education; structural equation modeling; biology education; intervention; teacher training

1. Introduction

The investigation of teachers' beliefs is an important area of research in science education literature [1–3]. Teachers' beliefs influence their planning and classroom practices, and reflect upon their practices [4,5]. This paper is devoted to the following important, but underrated, aspect of research concerning teachers' beliefs: the diversity of teachers' beliefs. Studied collectively, teachers hold a surprisingly large range of different beliefs regarding one topic [1,4,6]. For example, regarding cancer education, conducted interviews with teachers allowed us to identify numerous qualitatively different beliefs, ranging from the impact of teaching about cancer on their students' emotions to teachers' beliefs regarding the extent to which other people and stakeholders expect them to teach about the topic [7]. Knowledge of the range of different teachers' beliefs is a valuable resource for the planning and conducting of teacher training interventions aiming to strengthen favorable beliefs and weaken unfavorable beliefs [8].

Research investigating the diversity of teachers' beliefs typically aims to analyze the relationships between beliefs and other variables related to teaching and learning [9,10]. The following two options are used to achieve this aim: scale models and single item models [11]. For the formation of scales, data from several items sharing a common underlying construct are combined. Such data are called aggregate data [12]. For example, in the Cognitive Activation in the Mathematics Classroom and Professional Competence of Teachers (COACTIV) study, scales were formed for constructivist and transmissive beliefs about teaching and learning science, and each scale consisted of several

items [13,14]. In the COACTIV study, the analyses focused on how well transmissive and constructivist teacher beliefs (as aggregate data) predicted student achievement. Other researchers have used individual items to represent beliefs. Therefore, each item represents a qualitatively different belief. Such analyses focuses on the predictive value of each individual item for the other variables related to teaching and learning. This procedure was suggested by Fishbein and Ajzen [15], who proposed to investigate teachers' beliefs with single items and study the relationship between beliefs and other variables related to teaching and learning [16,17].

Both procedures can be expected to have advantages and disadvantages related to the two criteria of following common psychometric standards and adequately acknowledging the diversity of different beliefs. Compared to using single items, using scales has the advantage that groups of items can be analyzed to obtain internal consistency, and this process involves the common standards of reporting item discrimination indices and the Cronbach alpha coefficient [18]. This process is performed by classical item analyses to ensure psychometric standards [12,19]. However, the disadvantage of using scales is that beliefs can be highly specific, such that individual items may not fit any scale [20]. When these items are salient and express a belief that can be expected to be important based on theory, researchers are faced with the problem that this belief should not be ignored; however, such items that cannot be properly included in the scales need to be removed from the item pool, according to the standard procedures of scale development [19,21]. It is also possible that beliefs are highly diverse such that scaling is problematic because items with a low discriminative power result in scales lacking internal consistency [15]. Thus, based on the latter two reasons, using single items may be advantageous over using scales.

Prior to this study, we identified a wide range of teachers' beliefs about teaching cancer education [7]. It was possible to scale most beliefs, and the scales met the psychometric standards. However, the teachers also expressed salient beliefs that did not fit any scale, such as the belief that students would be emotionally affected by teaching about cancer and the belief that teachers felt ill prepared to address the psychosocial complexity of the topic [7]. Despite the standard procedures of scale development cited above, we recommended to retain these items for two reasons. First, teachers' beliefs focusing on the emotional aspects of teaching cancer and teachers' self-efficacy beliefs are considered important in cancer education literature [22–24]. Second, salient single items may potentially be important predictors of other variables related to teaching and learning about cancer [15,25]. We also argued that the calculation of the model fit indices could shed light on the empirical question of whether single item models or scale models should be preferred when analyzing the relationship between teachers' beliefs and other variables related to teaching and learning a topic. We were unable to answer this question because the previous study focused on test instrument development, and no information regarding the other variables was obtained.

Therefore, by using new data obtained from a different sample of biology teachers and including not only belief items but also items assessing other variables related to the teaching and learning of cancer (e.g., teachers' attitudes), in this study, we investigated the advantages and disadvantages of using either single item models or scale models in research concerning teachers' beliefs. Our analyses focus on the calculation of model fit indices and analyses of variance to determine which approach is more informative for identifying possible predictors of variables related to teaching and learning about cancer. This research is expected to be informative for teacher education researchers by providing guidance for making informed decisions when choosing between two approaches to address the diversity of teachers' beliefs.

2. Theoretical Background

Researchers typically apply psychological models to study the relationship between teachers' beliefs and other variables related to teaching and learning [1,26]. The theory of planned behavior is a prominent example. The theory of planned behavior [15,27] was originally developed in the context of health psychology and has increasingly been used in teacher education research during the last

decades to study the relationship between teachers' beliefs and other variables related to teaching and learning [28]. This theory has been applied to a wide range of different contexts, including grammar and mathematics education [29,30], integration of technology in the classroom [31,32], inclusive education [33–35];), and science education [28,36,37]. In these studies, using the theory of planned behavior contributed to the understanding that teachers' instructional decisions and classroom practices are largely influenced by psycho-social variables (i.e., factors related to a person's psychological state and social environment), which are informed by context-specific teachers' beliefs.

In general, the theory of planned behavior provides a model illustrating how teachers' beliefs are causally linked to teachers' behavior [38] (see Figure 1). Teachers' beliefs determine their attitudes, perceptions of social pressure, and perceived behavioral control. These constructs influence teachers' intentions to perform a behavior related to their professional practice. In turn, teacher intention is the only predictor of the teachers' behavior in the classroom, i.e., whether teachers actually perform a behavior [15].

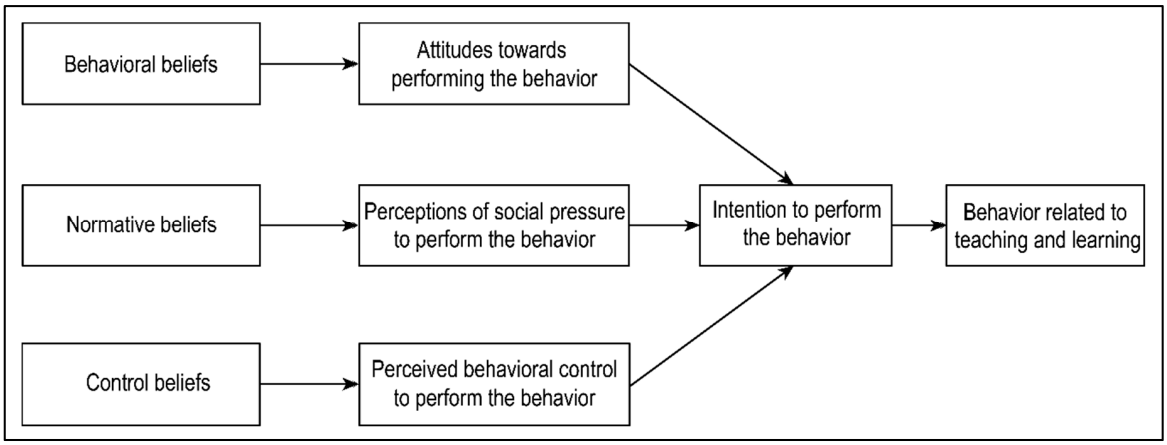

Figure 1. Schematic representation of the theory of planned behavior applied to teachers' behavior.

2.1. Reflecting upon the Role of Beliefs in the Theory of Planned Behavior

The authors of the theory of planned behavior generally defined beliefs as perceived probabilities that a person assigns a certain attribute to an object or behavior (e.g., "I believe that when teaching about cancer [behavior], students will likely react emotionally in the classroom [attribute]"). These authors distinguish among three types of beliefs, namely, behavioral beliefs, normative beliefs, and control beliefs (see Figure 1) [15].

Behavioral beliefs (BB) are beliefs about the positive and negative consequences of performing a behavior. Concerning teaching about cancer, the following belief is an example of a behavioral belief: "As a consequence of teaching about cancer, most of my students will become aware of carcinogenic risk factors". Behavioral beliefs determine teachers' attitudes (see Figure 1), such as the attitude "I find teaching about cancer easy/difficult" [39,40].

Normative beliefs (NB) are beliefs about other people's normative expectations concerning one's performance of behavior (injunctive normative beliefs, NBI) and beliefs about other people's behavior (descriptive normative beliefs, NBD). The following beliefs are examples of teachers' injunctive and descriptive normative beliefs: "Cancer education researchers expect me to teach about cancer" and "Other biology teachers in my school will also teach about cancer". Normative beliefs determine perceptions of social pressure (see Figure 1), which are defined as abstract judgements about the perceived social pressure to perform a behavior related to teaching and learning (e.g., "My social environment will expect me to teach about cancer") [41,42].

Control beliefs (CB) are beliefs about external factors influencing behavior (situational control beliefs, CBSIT) or beliefs about skills and abilities relevant to performing a behavior (personal control beliefs, CBPER). The following beliefs are examples of teachers' situational and personal control beliefs:

"There will be specific teacher trainings on cancer" and "When teaching about cancer, I will be able to answer students' biological questions about cancer". Control beliefs determine perceived behavioral control (see Figure 1), which is defined as an abstract evaluation of how a person perceives her or his capability (e.g., "I feel well prepared to teach about cancer") and the controllability of the behavior ("It is my own decision whether I teach about cancer") [43].

Education researchers consider this theory a useful framework for planning and evaluating tailored teacher training interventions predicated on teachers' beliefs [34,44–47]. Essentially, tailored interventions aim to change teachers' beliefs to induce changes in teachers' attitudes, perceptions of social pressure, and perceived behavioral control [8]. Furthermore, such changes are expected to result in changes in teachers' intentions and, ultimately, teachers' behavior [38].

2.2. Using the Theory of Planned Behavior to Model Beliefs

To model beliefs in the context of the theory of planned behavior, researchers typically apply statistical techniques, such as structural equation modeling (SEM) [12,28]. SEM serves as an umbrella term representing different techniques used to analyze the relationships among multiple variables [12,48]. For example, SEM can be used to calculate the extent to which teachers' beliefs predict their attitudes. A unique characteristic of SEM is that it provides an opportunity to simultaneously investigate observed variables and latent variables frequently used in education sciences studies. [12,48]. Observed variables represent data for which researchers have collected scores [12], including teachers' responses to belief items, such as "How likely do you believe that your teaching about cancer will lead students to have emotional reactions?" (i.e., a behavioral belief), with teacher responses ranging from 1 (very unlikely) to 7 (very likely). Latent variables correspond to hypothetical constructs that are not directly observable [12]. An example is teachers' attitudes towards teaching about cancer. To create a latent variable related to teachers' attitudes, researchers combine multiple observed variables such that each variable covers a single evaluative aspect of teaching about cancer through items, such as "teaching about cancer is good/bad", "teaching about cancer is easy/difficult", and "teaching about cancer is interesting/boring". The combined observed variables form a group of items called a multi-item scale [12,49,50].

To analyze teachers' beliefs, the research literature describes two models, namely, single item models and scale models. In single item models, each belief item is treated as an observed variable, and all other constructs of the theory of planned behavior (e.g., attitudes) are treated as latent variables [15,27,51]. For each belief item, researchers separately calculate how well the belief predicts attitudes, perceptions of social pressure, and perceived behavioral control using a special variant of SEM called the multiple indicators multiple causes (MIMIC) model [12,48,52,53]. In contrast, in scale models, the belief items are first combined to form multi-item belief scales that are treated as latent variables. For the belief scales, researchers investigate how well the scales predict attitudes, perceptions of social pressure, and perceptions of behavioral control using the standard SEM technique [12].

One reason for using these two types of models is that researchers follow two different perspectives. On the one hand, some researchers, including Fishbein and Ajzen [15], prefer to treat beliefs as observed variables and recommend the use of single item models. These researchers argue that belief items usually cover too many different aspects and, therefore, cannot be combined to form multi-item scales [51–53]. According to education sciences researchers, single item models provide information regarding the relative weight of teachers' beliefs, which can be used to plan teacher training interventions addressing the beliefs that have the greatest relative weight [8].

On the other hand, other researchers prefer to combine belief items into multi-item scales and treat belief scales as latent variables [20,21,54]. This procedure is based on the assumption that belief items share a common underlying construct (e.g., positive consequences of teaching about cancer; [20]). Scales can be tested to assess reliability, whereas single items cannot be tested for reliability [55,56]. The term reliability refers to the overall consistency of a scale [57]. The reliability of a scale is high when it produces similar results under similar conditions. Scale reliability is typically assessed through

measures, such as Cronbach's Alpha coefficient (α) or McDonald's Omega coefficient (ω), that range from 0 to 1 [58,59]. The reliability of a scale is considered acceptable when the α and ω coefficients are ≥0.70 [58]. Often, belief scales developed in the context of the theory of planned behavior, such as scales addressing beliefs related to physical activity, exhibit higher reliability coefficients [60]. However, due to the heterogeneity of teachers' beliefs, researchers sometimes have to use scales exhibiting lower reliability coefficients. For example, studies in the field of mathematics teacher education (i.e., Mathematics Teaching in the 21st Century (MT21) and COACTIV) assessed teachers' transmissive and constructivist beliefs using scales and revealed Cronbach's α coefficients ranging between 0.55–0.64. [13,14]). However, this scale did not differentiate among the three different types of beliefs addressed in this paper because the beliefs were not studied in the context of the theory of planned behavior.

2.3. Teachers' Beliefs about Teaching Cancer Education

Teachers have expressed the belief that teaching about cancer education is challenging because of the complexity of the topic and its emotional psychosocial implications [22–24,61]. Therefore, Heuckmann et al. [62] employed the theory of planned behavior to investigate teachers' beliefs about teaching cancer education in German high schools. In two preparatory studies, the authors developed questionnaires assessing attitudes, social norms, perceived behavioral control, intention [63] and behavioral, normative, and control beliefs [7]. Heuckmann et al. [7] used open-ended questionnaires and interviews to elicit teachers' beliefs about teaching cancer education. In total, 49 items aligned with the behavioral, normative, and control belief constructs of the theory of planned behavior were generated. Both questionnaires from [7,63] were combined in a study described by [62]. In their study, Heuckmann et al. [62] first analyzed the predictive power of attitudes, social norms, and perceived behavioral control on teachers' intentions to teach about cancer using structural equation models. To prevent ceiling effects for intention (i.e., cancer education became a mandatory topic in the biology curriculum at the time the study was conducted), the teachers were also encouraged to indicate how willing they would be to teach about cancer education if teaching the topic was obligatory. Attitudes were identified as the strongest predictors of teacher willingness to teach about cancer. Second, the authors examined the extent to which the teachers' behavioral, normative, and control beliefs could be used to predict attitudes, social norms, and perceived behavioral control. A single item model was built for this purpose following Fishbein and Ajzen's [15] recommendation to treat beliefs as observed variables. This model enabled the identification of the belief items that were the strongest predictors of attitudes, social norms, and perceived behavioral control.

For each belief, the study participants were assessed on the following two items: belief likelihood judgments and belief evaluation judgments. Fishbein and Ajzen [64] and other scholars [65–67] recommend using this approach to acknowledge that people may differ in their evaluation of beliefs. To illustrate the difference between likelihood judgement and evaluation judgement, we discuss the following belief: teaching about cancer will cause controversial discussions regarding vaccinations against human papilloma virus to prevent cervical cancers. Teachers may differ in their perception of the likelihood that discussions of this type will emerge (e.g., very unlikely to very likely) and their evaluation of this belief as some teachers may find this type of discussion more problematic than other teachers [7]. Thus, researchers utilize two different measures (belief likelihood judgements and belief evaluation judgements) and form a multiplicative product of both measures, i.e., the expectancy-value product (EVP).

In [62], Heuckmann et al. used the EVP as a criterion to combine belief items into belief scales. Beliefs with a positive mean EVP were combined into one scale, whereas items with a negative mean EVP were combined into other scales. Following this procedure, it was possible to form the following five reliable belief scales: "situational control beliefs: external inhibitors" (α = 0.81, 10 items), "personal control beliefs: internal facilitators" (α = 0.80, 6 items), "behavioral beliefs: positive

consequences" (α = 0.82, 10 items), "injunctive normative beliefs: irrelevant referents" (α = 0.82, 3 items), and "descriptive normative beliefs: positive role models" (α = 0.96, 5 items).

During the scale formation in [7], Heuckmann et al. encountered the methodological issue that not all belief items in a scale showed sufficient discriminatory power (r_{it} > 0.30; [50]). As a common practice in test development, such low-discriminatory items should be removed from the item pool [55]. However, Heuckmann et al. [7] argued that the removal of these salient belief items from the item pool could diminish the validity of the approach because the teachers had formulated their beliefs in interviews, and the analyses showed that these beliefs were salient. By definition, salient beliefs are readily accessible in the teachers' minds and influence their behavioral decisions. Thus, removing items that represent salient beliefs from the item pool for purely statistical reasons could be questionable. Furthermore, a high discriminatory power or a high internal consistency is not necessarily expected for all belief items in a belief scale [15] (p. 105). Given these methodological issues in forming reliable belief scales, Heuckmann et al. [7] concluded that there are two variants for modeling beliefs in the context of the theory of planned behavior as follows: beliefs can be treated as observed variables and analyzed in single item models or treated as latent variables and analyzed in belief scale models in which the EVP is used to aggregate beliefs in belief scales.

3. Research Question

Contributing to the methodological discussion regarding how to model beliefs in the context of the theory of planned behavior [20,68], this study compares the two variants of modeling beliefs proposed by [7] in the context of cancer education. For this purpose, beliefs are modeled either as single item models or scale models, and the modeling results are compared in terms of the model fit indices, explained variance, and predictive power of attitudes, social norms, and perceived behavioral control. The research question is as follows: In the context of teaching about cancer, to what extent do single item models and scale models differ in their predictive power of attitudes, social norms, and perceived behavioral control?

The evaluation of the two variants of modeling beliefs is considered from the perspective of using the theory of planned behavior for planning interventions (i.e., designing teacher-training interventions); thus, the practical implications of the different models are also discussed [69].

4. Methods

4.1. Study Design

To answer the research question, the data used included answers from n = 355 biology teachers on measures of attitudes, social norms, perceived behavioral control [63] and behavioral, normative, and control beliefs [7]. The data were collected via an online survey. A planned missing data design [70] consisting of three test booklets that provided complete responses for attitudes, social norms, and perceived behavioral control and one-third missing data on the belief-based measures (missing completely at random (MCAR)) was used. The items used to measure beliefs were rotated among the three booklets such that all participants answered two-thirds of the belief items and all items related to attitudes, social norms, and perceived behavioral control. This approach led to a substantial reduction in the number of items per questionnaire (from 163 items in the pilot study to 127 items in the main study) and considerably reduced the test time and participant fatigue (from approximately 25 min in the pilot study to 15 min in the main study). Prior to the statistical data analysis, the missing data were imputed [71]. For the imputation, we used multivariate imputation by the chained equations (MICE) technique [72] in R (version 3.5.3) [73]. We used an algorithm that imputed the missing data from those cases that showed complete answers (i.e., "predictive mean matching" [74]). This approach ensures that the imputed values do not exceed the range of possible values. In addition, this approach is largely robust against deviation from multivariate normality as was observed in the data. A detailed description of the study design and sample is provided in a previous study by Heuckmann et al. [62].

4.2. Measuring the Theory of Planned Behavior Variables

To assess attitudes towards teaching cancer education, two scales, namely, "attitudes towards the perceived burden of teaching about cancer" (AB-B, 4 items, Cronbach's $\alpha = 0.79$, McDonald's $\omega = 0.79$) and "attitudes towards the perceived necessity of teaching about cancer" (AB-N, 3 items, $\alpha = 0.77$, $\omega = 0.80$), were used. To assess social norms, one scale, namely, "perceived social pressure to teach about cancer" (SN, 4 items, $\alpha = 0.82$, $\omega = 0.82$), was used. Two scales, namely, "perceived autonomy in teaching about cancer" (PBC-A, 4 items, $\alpha = 0.77$, $\omega = 0.74$) and "self-efficacy in teaching about cancer" (PBC-SE, 3 items, $\alpha = 0.84$, $\omega = 0.85$), were used to assess perceived behavioral control. All scales showed good reliability [58]. All items were adapted from a study by Heuckmann et al. [63].

Twelve behavioral beliefs, twelve normative beliefs (six items each for injunctive and descriptive normative beliefs), and 25 control beliefs (17 situational control beliefs and eight personal control beliefs) were measured in terms of belief likelihood judgments and belief evaluation judgments. The measures of beliefs consisted of seven-point unipolar rating scales for the belief likelihood judgments and seven-point bipolar rating scales for the belief evaluation judgments. EVPs were calculated as the multiplicative product of the belief likelihood and belief evaluation judgements of each item. Tables 3–6 in the results section provide an overview of all belief-based measures used in this study. The belief items were aggregated into belief scales according to the mean EVP. This approach resulted in unidimensional scale models when all belief items had a positive EVP (i.e., behavioral beliefs) and two-dimensional scale models when the belief items had positive and negative EVPs (i.e., situational control beliefs). Table 1 provides an overview of the scales used. To assess the belief-based measures, we used the items described in [7,62]. Cronbach's α and McDonald's ω were used to assess the reliability of the belief scales; values ≥ 0.70 were deemed sufficient [58]. However, not all scales showed sufficient reliability (see Table 1).

Table 1. Overview of the belief-scale characteristics.

	Scale	Items	α	ω
	Behavioral beliefs			
BB	"positive consequences"	12	0.84	0.86
	Normative beliefs			
NBI	"relevant referents"	3	0.43	0.41
NBI	"irrelevant referents"	3	0.80	0.83
NBD	"positive role models"	6	0.88	0.87
	Control beliefs			
CBPER	"internal facilitators"	8	0.70	0.64
CBSIT	"external facilitators"	7	0.45	0.29
CBSIT	"external inhibitors"	10	0.45	0.30

BB = behavioral beliefs; NBI = injunctive normative beliefs; NBD = descriptive normative beliefs; CBSIT = situational control beliefs; CBPER = personal control beliefs; α = Cronbach's α; ω = McDonald's ω.

4.3. Analyzing the Belief-Based Measures and Their Relationships with Attitudes, Social Norms, and Perceived Behavioral Control

We calculated the descriptive statistics (mean and standard deviation) of all belief items used in the study. As suggested by Bleakley and Hennessy [20], separate structural equation models were used to investigate the relationships between behavioral beliefs and attitudes, between normative beliefs and social norms, and between control beliefs and perceived behavioral control. For each relationship, a single item model and a scale model were specified. To calculate the predictive power of the beliefs in both model variants, we entered the pooled double-mean-centered EVP into the structural equation model as recommended by Lin et al. [75]. We report the standardized regression coefficients (β-values) to allow a comparison of the relative power of the belief predictors across the models [12]. The software packages "lavaan" (version 0.6-4.1384) [76] and "semTools" (version 05-1.197) [77] in

R (version 3.5.3) [73] were used to calculate the structural equation models. A robust estimator was chosen to avoid bias in the parameter estimation due to nonnormality [78].

To assess the instrument quality of the single item model and scale model, we calculated the model fit indices as recommended by Schermelleh-Engel et al. [79] and evaluated these indices according to the boundaries of an acceptable model fit as follows: χ^2/df ratio ≤ 3, comparative fit index (CFI) ≥ 0.90, and root mean square error of approximation (RMSEA) ≤ 0.08. In addition, the Akaike information criterion (AIC) and Bayesian information criterion (BIC) were determined to identify the model that better fit the data [12]. Table 2 shows the model fit indices of both modeling variants.

Table 2. Comparison of the model fit indices of the single item and belief-scale models.

Index	Behavioral Beliefs		Injunctive Normative Beliefs	
	Single Item Model	**Scale Model (1D)**	**Single Item model**	**Scale Model (2D)**
χ^2 (df/p)	3151.294 (71/.000)	4623.779 (111/.000)	530.881 (11/.000)	945.661 (24/.000)
CFI	0.856	0.901	0.941	0.947
RMSEA (95% CI)	0.082 (0.079–0.084)	0.080 (0.078–0.082)	0.083 (0.077–0.089)	0.081 (0.076–0.085)
AIC	140,242	725,522	74,240	348,259
BIC	140,522	726,062	74,328	348,464
	Descriptive normative beliefs		Personal control beliefs	
	Single item model	Scale model (1D)	Single item model	Scale model (1D)
χ^2 (df/p)	273.843 (11/.000)	587.093 (24/.000)	516.404 (16/.000)	1747.961 (40/.000)
CFI	0.972	0.983	0.955	0.922
RMSEA (95% CI)	0.054 (0.049–0.060)	0.063 (0.058–0.067)	0.069 (0.064–0.074)	0.081 (0.078–0.085)
AIC	74,771	347,487	66,310	447,917
BIC	74,860	347,630	66,406	448,095
	Situational control beliefs			
	Single item model	Scale model (2D)		
χ^2 (df/p)	1381.665 (50/.000)	6946.585 (179/.000)		
CFI	0.88	0.669		
RMSEA (95% CI)	0.062 (0.059–0.65)	0.080 (0.079–0.082)		
AIC	98,488	784,394		
BIC	98,679	784,749		

1D = unidimensional belief-scale model; 2D = two-dimensional belief-scale model.

5. Results

The findings obtained from the statistical analysis are presented in Tables 3–6. The tables are organized as follows: the tables are separated by behavioral (see Table 3), normative (see Table 4), and control beliefs (see Tables 5 and 6). The tables describe how many beliefs were assessed for each type of belief and present the belief scales that were formed. The first three columns of each table present the item numbers, a description of the belief content (aspect of the belief content) and the belief items. Columns four and five of each table present the item means and standard deviations of the belief likelihood judgements and belief evaluation judgements used to provide insight into the diversity of the teachers' beliefs (Section 5.1). Column six of each table presents the multiplicative product of the belief likelihood and belief evaluation judgements, i.e., the expectancy-value-product (EVP), which was used to align the belief items to the scales. The final column describes the standardized regression coefficient beta (β) used to analyze how well the belief items and belief scales predict teacher attitudes, perceptions of social pressure, and perceived behavioral control (Sections 5.2–5.4). The β-value

indicates the relative impact of a predictor variable (single belief items and belief scales) on an outcome variable (teacher attitudes, perceptions of social pressure, and perceived behavioral control). This value represents how strongly the outcome variable would change if the predictor variable changes by one unit (i.e., increases by one standard deviation) [50]. The minor differences between the regression coefficients presented here and those presented by Heuckmann et al. [62] are due to the fact that during the data preparation, the present study applied 20 imputations as recommended by Graham et al. [80], while Heuckmann et al. [62] applied 50 imputations as recommended by Enders [71].

5.1. Selected Insight into Teachers' Beliefs about Teaching Cancer Education

Regarding behavioral beliefs, the teachers rated the following consequences of cancer education as likely and positive (see columns four and five of Table 3): teaching about cancer increases student interest, motivation, and knowledge of cancer risk factors; helps students challenge media reports about cancer, thus reducing their burden of cancer; and encourages students to ask medical questions. The teachers also evaluated the following consequences as positive: some students might be emotionally affected by cancer, and students will ask cancer-related questions that do not have a clear scientific answer.

Regarding the normative beliefs, the teachers reported that students, other biology teachers, and people with cancer likely expect teachers to teach about cancer (see column four of Table 4). The surveyed teachers were motivated to comply with these expectations (see column five of Table 4). The teachers also believed that physicians, health insurance companies, and cancer researchers expected them to teach about cancer. However, the teachers were not motivated to comply with these expectations. Furthermore, the teachers considered it likely that other biology teachers also teach about cancer. However, most surveyed teachers expressed low identification with other biology teachers' behaviors related to teaching about cancer.

Regarding the situational control beliefs (see columns four and five of Table 5), the teachers assessed it as likely and helpful for cancer education if textbooks extensively covered the topic of cancer and teacher-training courses on cancer education were provided. Teachers assessed it as unlikely but helpful for cancer education that ready-to-use teaching materials about cancer are easy to acquire, teaching about cancer is obligatory by the curriculum, students are interested in learning about cancer, and teaching about cancer allows highlighting the connections between genetics and cell biology. Furthermore, the teachers rated the following aspects as likely and inhibiting for cancer education: students have misconceptions about cancer, are challenged by the complexity of the issue, have personal experiences with cancer, and are afraid to discuss cancer. The teachers also reported the following hindrances for cancer education: preparing lessons related to cancer is time consuming, limited time is available to address the emotional aspects of cancer and the upper-secondary biology curriculum is comprehensive. However, the teachers assessed these aspects as less likely to occur.

Regarding personal control beliefs (see columns four and five of Table 6), the teachers rated it as likely and helpful for cancer education that they can address the psychosocial and emotional aspects of cancer, answer students' questions about cancer, and talk to colleagues about cancer education. The teachers also considered it likely and helpful that they became familiar with the biological background of cancer prior to teaching about the topic. Moreover, the teachers considered being knowledgeable about the students' family history of cancer unlikely. However, the teachers considered such knowledge helpful in teaching about cancer.

Table 3. Descriptive statistics of the likelihood judgments, evaluation judgments, expectancy-value products, and predictive power of behavioral beliefs.

Item Number	Aspect of Belief Content	Item	Likelihood Judgment		Evaluation Judgment		Expectancy-Value Product		β-Value	
			Mean	SD	Mean	SD	Mean	SD	AB-B	AB-N
	Scale: "Behavioral beliefs: positive consequences" (12 items)								−0.131 ***	0.596 ***
BB1	students' interest	By teaching about cancer, most students' interest in biology will increase.	5.50	1.23	2.60	0.68	14.51	5.19	−0.037 ^{ns}	0.277 ***
BB2	teachers' knowledge	By teaching about cancer, I will gain knowledge about cancer.	5.97	1.20	2.62	0.78	15.99	5.84	0.265 ***	0.011 ^{ns}
BB3	students challenging media reports	By teaching about cancer, most students will be capable of challenging media reports on cancer.	5.02	1.28	2.64	0.66	13.47	5.04	0.024 ^{ns}	−0.054 ***
BB4	cancer risk factors	Most of my students will become aware of carcinogenic risk factors.	5.70	1.27	2.75	0.56	15.90	5.07	−0.089 ***	0.091 ***
BB5	students' questions	When teaching about cancer, there will be some questions about cancer that do not have a clear scientific answer.	6.17	1.05	1.50	1.34	9.37	8.83	−0.201 ***	−0.184 ***
BB6	cancer education as a burden	By teaching about cancer, most students' uncertainty about how to address cancer will be removed.	4.54	1.36	2.34	1.06	10.83	6.22	−0.056 ***	0.232 ***
BB7	emotional reactions	Most students will be emotionally affected while teaching about cancer.	4.63	1.45	0.42	1.29	2.54	6.56	−0.137 ***	−0.072 ***
BB8	scientific research	When teaching about cancer, career options in scientific research will be discussed.	4.55	1.69	2.06	0.98	10.00	6.41	−0.090 ***	0.060 ***
BB9	students' questions	When teaching about cancer, some students will ask medical questions about cancer.	6.55	0.87	2.19	1.01	14.57	7.10	0.001 ^{ns}	0.198 ***
BB10	connections between real life and school	By teaching about cancer, students will realize how the teaching content is connected to their lives.	6.24	1.11	2.73	0.60	17.30	5.23	−0.011 ^{ns}	0.108 ***
BB11	emotional reactions	Some students will react emotionally while teaching about cancer.	5.34	1.37	0.80	1.05	4.65	6.10	0.309 ***	0.177 ***
BB12	students' motivation	By teaching about cancer, some students' motivation to learn will increase.	5.57	1.19	2.73	0.60	15.37	4.95	−0.223 ***	−0.012 ^{ns}

BB = behavioral beliefs; AB-B = attitudes towards the perceived burden of teaching about cancer; AB-N = attitudes towards the perceived necessity of teaching about cancer; ^{ns} not significant; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$; β = standardized regression weights from the single item models and belief-scale models; all calculations are based on the imputed data set.

Table 4. Descriptive statistics of the likelihood judgments, evaluation judgments, expectancy-value products, and predictive power of normative beliefs.

Item Number	Aspect of Belief Content	Item	Likelihood Judgment		Evaluation Judgment		Expectancy-Value Product		β-Value of SN
			Mean	SD	Mean	SD	Mean	SD	
	Scale "Normative beliefs: relevant referents" (3 items)								0.436 ***
NBI1	students	Students in my biology class will expect me to teach about cancer.	4.72	1.95	1.58	1.39	8.57	7.55	0.113 ***
NBI3	other biology teachers	My colleagues will expect me to teach about cancer.	5.40	1.71	0.47	1.72	3.36	9.71	−0.016 ^{ns}
NBI4	people with cancer	People who have cancer will expect me to teach about cancer.	4.18	1.87	0.15	1.61	1.63	7.22	0.225 ***
	Scale "Normative beliefs: irrelevant referents" (3 items)								−0.075 *
NBI2	physicians	Physicians expect me to teach about cancer.	4.27	1.82	−0.29	1.60	−0.33	7.35	0.090 **
NBI5	health insurance companies	Health insurance companies expect me to teach about cancer.	4.07	1.93	−1.13	1.52	−3.82	6.77	−0.104 ***
NBI6	cancer researchers	Cancer researchers expect me to teach about cancer.	4.82	1.91	−0.12	1.66	0.37	8.34	0.051 *
	Scale "Normative beliefs: positive role models" (6 items)								0.124 ***
NBD1	other biology teachers	Other biology teachers will also teach about cancer.	6.45	0.88	0.54	1.51	3.79	10.00	0.009 ^{ns}
NBD2	male biology teachers	Male biology teachers will also teach about cancer.	6.32	1.07	0.29	1.52	2.25	9.85	−0.148 ***
NBD3	female biology teachers	Female biology teachers will also teach about cancer.	6.45	0.86	0.39	1.51	2.75	10.03	0.175 ***
NBD4	younger biology teachers	Younger biology teachers will also teach about cancer.	6.34	1.05	0.66	1.49	4.52	9.82	0.107 ***
NBD5	older biology teachers	Older biology teachers will also teach about cancer.	5.52	1.55	0.08	1.52	1.38	8.75	−0.066 ***
NBD6	relation to students	Teachers who have a trusting relationship with their students will also teach about cancer.	6.37	0.98	1.52	1.31	10.10	8.83	0.092 ***

NBI = injunctive normative beliefs; NDB = descriptive normative beliefs; SN = perceived social pressure to teach about cancer; ^{ns} not significant; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$; β = standardized regression weights from the single item models and belief-scale models; all calculations are based on the imputed data set.

Table 5. Descriptive statistics of the likelihood judgments, evaluation judgments, expectancy-value products, and predictive power of situational control beliefs.

Item Number	Aspect of Belief Content	Item	Likelihood Judgment		Evaluation Judgment		Expectancy-Value Product		β-Value of PBC-A
			Mean	SD	Mean	SD	Mean	SD	
	Scale "Control beliefs: external facilitators" (7 items)								0.496 ***
CBSIT1	availability of teaching materials.	When teaching about cancer, appropriate teaching materials will be available.	3.91	1.89	2.55	0.85	9.99	6.24	−0.103 ***
CBSIT2	curriculum guidelines	Cancer will be a compulsory topic in the curriculum.	2.38	2.13	0.50	1.31	1.54	4.81	0.171 ***
CBSIT7	factual complexity of cancer	There will be a great amount of possible content for lessons about cancer.	3.01	1.79	0.14	1.53	0.35	5.32	0.084 ***
CBSIT8	cancer connecting genetics and cell biology	When teaching about cancer, "cell biology" and "genetics" can be linked.	2.13	1.79	1.36	1.25	2.45	4.14	−0.077 ***
CBSIT11	availability of teaching materials	The textbooks used at my school will extensively cover the issue of cancer.	4.25	1.75	1.99	1.42	8.53	7.66	0.013 ^{ns}
CBSIT14	student motivation	Most students will be interested in the topic of cancer.	2.54	1.70	2.45	0.86	5.89	4.56	−0.014 ^{ns}
CBSIT15	opportunities for teacher trainings	There will be specific teacher trainings related to cancer.	4.02	1.89	2.14	1.04	8.50	6.18	−0.042 **
	Scale "Control beliefs: external inhibitors" (10 items)								0.553 ^{ns}

Table 5. *Cont.*

Item Number	Aspect of Belief Content	Item	Likelihood Judgment		Evaluation Judgment		Expectancy-Value Product		β-Value of PBC-A
			Mean	SD	Mean	SD	Mean	SD	
CBSIT3	student knowledge	Most students will hold misconceptions about the biology of cancer.	3.20	1.61	−0.36	1.13	−1.32	4.24	0.086 ***
CBSIT4	student affectedness	Most students will be faced with cancer in their social environment (friends or families).	3.05	1.56	−0.44	1.30	−1.28	4.68	−0.012 ^{ns}
CBSIT5	student affectedness	Students who are personally affected by cancer will prefer to not discuss cancer in the classroom.	3.99	1.42	−0.75	1.12	−2.92	4.92	0.006 ^{ns}
CBSIT6	student affectedness	Students might have experienced the death of someone from their social environment (friends or families) due to cancer.	2.67	1.47	−1.09	1.09	−2.76	3.49	0.102 ***
CBSIT9	lack of time	Preparing lessons about cancer will be time consuming.	2.67	1.63	−1.25	1.28	−3.11	4.19	0.066 ***
CBSIT10	tightly packed curricula	Overall, the curricular guidelines for senior biology classes will be lengthy.	2.88	1.81	−1.32	1.37	−3.29	5.06	0.117 ***
CBSIT12	emotional complexity of cancer	Time to address the emotional aspects of cancer may be lacking when teaching about cancer in secondary biology classes.	2.91	1.79	−1.38	1.19	−3.96	4.77	0.006 ^{ns}
CBSIT13	overwhelmed students	Some students will be overwhelmed by the complexity of cancer.	2.83	1.69	−1.56	0.97	−3.98	3.67	−0.012 ^{ns}
CBSIT16	emotional and factual complexity of cancer	When teaching about cancer, the factual and emotional aspects of cancer will be indivisible.	3.55	1.72	−0.26	1.21	−1.48	5.04	−0.191 ***
CBSIT17	emotional complexity of cancer	When teaching about cancer, aspects, such as "death" and "dying", will emerge in the classroom.	2.90	1.86	−0.05	0.98	−0.39	3.47	0.110 ***

CBSIT = situational control beliefs; PBC-A = perceived autonomy to teach about cancer; ^{ns} not significant; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$; β = standardized regression weights from the single item models and belief-scale models; all calculations are based on the imputed data set.

Table 6. Descriptive statistics of the likelihood judgments, evaluation judgments, expectancy-value products, and predictive power of personal control beliefs.

Item Number	Aspect of Belief Content	Item (Item Stem): When Teaching about Cancer	Likelihood Judgment		Evaluation Judgment		Expectancy-Value Product		β-Value of PBC-SE
			Mean	SD	Mean	SD	Mean	SD	
Scale "Control beliefs: internal facilitators" (8 items)									0.430 ***
CBPER1	addressing emotionally laden situations	… I will be able to address the psychosocial and emotional aspects of cancer.	5.27	1.65	1.71	1.11	9.27	6.75	0.097 ***
CBPER2	diversity of potential contexts	… I will be able to teach about the diversity of cancer types.	4.04	1.77	1.88	1.19	8.16	6.72	0.113 ***
CBPER3	teachers' content knowledge	Prior to my lessons on cancer, I will first have to become acquainted with the biology of cancer.	5.64	1.32	0.17	1.80	1.20	10.85	−0.260 ***
CBPER4	knowledge about students' personal background	… I will know which students have a family member suffering from cancer.	3.29	1.75	0.61	1.6	1.84	6.07	0.013 ^{ns}
CBPER5	answering biological questions	… I will be able to answer students' biological questions about cancer.	5.37	1.20	2.33	0.90	12.79	6.02	0.304 ***
CBPER6	discussing the topic with colleagues	… I will be able to discuss teaching about cancer with my colleagues.	5.42	1.45	2.18	0.99	12.45	6.98	−0.029 *
CBPER7	answering medical questions	… I will be able to answer students' medical questions about cancer.	4.66	1.37	2.26	0.95	10.87	5.83	0.030 ^{ns}
CBPER8	diversity of carcinogenic risk factors	… I will be able to teach about a variety of carcinogenic risk factors.	5.14	1.52	2.16	1.07	11.73	6.81	0.068 ***

CBPER = personal control beliefs; PBC-SE = self-efficacy to teach about cancer; ^{ns} not significant; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$; β = standardized regression weights from the single item models and belief-scale models; all calculations are based on the imputed data set.

5.2. Assessing the Relationships between Behavioral Beliefs and Attitudes

In the single item model, nine of the twelve behavioral beliefs were significant predictors of "attitudes towards the perceived burden of teaching about cancer" (AB-B, $R^2 = 0.205$). Items BB11 (ß = 0.309; students will react emotionally while teaching), BB2 (ß = 0.265; teaching about cancer will increase teacher knowledge about cancer), and BB12 (ß = −0.223; teaching about cancer will increase student motivation to learn) were the strongest predictors of the teachers' perceived burden (see final column of Table 3). Ten of the twelve behavioral beliefs were significant predictors of "attitudes towards the perceived necessity of teaching about cancer" (AB-N, $R^2 = 0.386$), and items BB1 (ß = 0.227; teaching about cancer increases student interest in biology) and BB6 (ß = 0.232; teaching about cancer will remove the students' uncertainty about how to address cancer) were the strongest predictors.

In the scale model, "attitudes towards the perceived burden of teaching about cancer" (AB-B, ß = −0.131; $R^2 = 0.017$) and "attitudes towards the perceived necessity of teaching about cancer" (AB-N; ß = 0.596, $R^2 = 0.355$) were significantly predicted by the scale "behavioral beliefs: positive consequences" (see final column of Table 3). Thus, the more likely the teachers consider teaching about cancer to have positive consequences, the greater they perceive the necessity to teach about cancer, and the less they perceive teaching about cancer as a burden.

5.3. Assessing the Relationships between Normative Beliefs and Social Norms

In the single item model, five of the six injunctive normative beliefs were significant predictors of "perceived social pressure to teach about cancer" (SN, $R^2 = 0.105$). The strongest predictor was item NBI4 (ß = 0.225; expectation of people with cancer, see final column of Table 6). In the scale model, "perceived social pressure to teach about cancer" (SN, $R^2 = 0.149$) was significantly predicted by the two scales "normative beliefs: relevant referents" (ß = 0.436) and "normative beliefs: irrelevant referents" (ß = −0.075), but due to the magnitude of the regression coefficients, only the scale "normative beliefs: relevant referents" has practical relevance (see final column of Table 4). Thus, the more other people expect teachers to teach about cancer and the more teachers are motivated to comply with these expectations ("relevant referents"), the more teachers perceive social pressure to teach about cancer.

In the single item model, five of the six descriptive normative beliefs were significant predictors of "perceived social pressure to teach about cancer" (SN, $R^2 = 0.105$). The two strongest predictors were items NBD2 (ß = −0.148; whether male biology teachers teach cancer education) and NDB3 (ß = 0.175; whether female biology teachers teach cancer education, see final column of Table 4). In the scale model, "perceived social pressure to teach about cancer" (SN, $R^2 = 0.015$) was significantly predicted by the scale "normative beliefs: positive role models" (ß = 0.124, see final column of Table 4). Thus, perceived social pressure to teach about cancer increases with the likelihood that other biology teachers with whom the surveyed teachers identify will also teach about cancer.

5.4. Assessing the Relationships between Control Beliefs and Perceived Behavioral Control

In the single item model, eleven of the 17 situational control beliefs were significant predictors of "perceived autonomy to teach about cancer" (PBC-A, $R^2 = 0.137$). The strongest predictors were items CBSIT2 (ß = 0.171; teaching about cancer is under curricular obligation) and CBSIT16 (ß = −0.191; the need to address the factual and emotional complexity of cancer, see final column of Table 5). In the scale model, "perceived autonomy to teach about cancer" (PBC-A, $R^2 = 0.105$) was significantly predicted by the scale "control beliefs: external facilitators" (ß = 0.496) but was not significantly predicted by the scale "control beliefs: external inhibitors" (ß = 0.553, $p = 0.253$, see final column of Table 5). Thus, the more likely that external circumstances render cancer education easier, the stronger the teachers' sense of autonomy in teaching about cancer.

In the single item model, seven of the eight personal control beliefs were significant predictors of "self-efficacy to teach about cancer" (PBC-SE, $R^2 = 0.247$). The strongest predictors were CBPER5 (ß = 0.304; possessing the knowledge necessary to answer students' biological questions about cancer)

and CBPER2 (ß = −0.260; teachers have the ability to address the diversity of the potential contexts of teaching about cancer, see final column of Table 6). In the scale model, "self-efficacy to teach about cancer" (PBC-SE, $R^2 = 0.185$) was significantly predicted by the scale "control beliefs: internal facilitators" (ß = 0.430, see final column of Table 6). Thus, the more knowledge and skills facilitating teaching about cancer the teachers believe they possess, the more likely they believe that they possess self-efficacy to teach about cancer.

6. Discussion

In this study, applying the theory of planned behavior to teachers' beliefs enabled us to analyze the relationship between teachers' beliefs and other variables related to teaching and learning. As suggested by the theoretical framework of the theory of planned behavior, we investigated the predictive power of teachers' behavioral, normative, and control beliefs on teachers' attitudes, perceptions of social norms, and perceived behavioral control in the context of teaching about cancer. The following two different options are discussed in the literature: using either single item models or scale models.

Both options, i.e., single item models and scale models, assisted us in identifying the predictive power of teachers' beliefs on other variables related to teaching and learning about cancer education and, therefore, enhanced our understanding of teachers' beliefs in the context of cancer education. However, the statistical analyses of the model fit indices (AIC/BIC) and explained variance (R^2) did not prove that either of the two model variants is superior over the other. For example, the single item models usually explained more variance (R^2) than the scale models, but the findings regarding the scales of injunctive normative beliefs contradicted this statement. Regarding the personal control beliefs and injunctive and descriptive normative beliefs, both model variants exhibited an acceptable model fit. Regarding the behavioral beliefs and situational control beliefs, both model variants had a poor model fit. Furthermore, if single item models and scale models are regarded as competitive models, the smaller AIC/BIC values consistently supported the use of single item models [79]. However, notably, the single item models were calculated using single items that, per definition, contain fewer parameters to be estimated, resulting in lower information criterion values [48].

In light of the findings of this study, it is impossible to conclusively determine whether single item models or scale models are "better" than the other models. However, we observed that both models have specific advantages and disadvantages for research concerning teachers' beliefs and entail methodological challenges during the statistical analysis. Furthermore, we draw implications on using single item models and scale models for planning teacher-training interventions. We discuss these aspects below.

6.1. Advantages and Disadvantages of Using Single Item Models

Using single item models allowed us to identify the behavioral, normative, and control beliefs that exerted the strongest statistical influence on attitudes, social pressure and perceived behavioral control [62]. These beliefs are promising starting points for interventions as they should facilitate change in teachers' attitudes, social norms, and perceived behavioral control [8]. Researchers can use the single item models to consider a full range of different belief items. This model adequality acknowledges the diversity of teachers' beliefs because there is no need to discard any belief items for statistical reasons [12].

As a disadvantage, the use of single item models confronts researchers with the issue that many beliefs were identified as significant predictors but had a low predictive power. More specifically, the magnitude of the situational control beliefs that significantly predicted perceived behavioral control ranged between $\beta = |0.191|$ and $\beta = |0.042|$. This finding poses the following questions for which there are no definitive answers in the literature: When is the predictive power of beliefs strong enough to be addressed in an intervention, and how can one choose between beliefs that have similar predictive power (an intervention cannot aim to change all types of different beliefs [8])? In addition, a drawback of using single item models with a high number of manifest, single-item indicators is that, by chance,

the probability of identifying beliefs as significant predictors that are not truly predictive increases (inflated type I error rate ([81], (p. 14)).

6.2. Advantages and Disadvantages of Using Belief-Scale Models

In general, an advantage of using belief scales is that the use of (reliable) belief scales allow statements based on aggregate data to be made concerning the predictive power of groups of beliefs (i.e., how beliefs about the positive consequences of teaching about cancer affect teacher attitudes). For such statements to be meaningful, forming a (reliable) belief scale is necessary and implies that the belief items included in the scale share a common construct (i.e., all beliefs address the positive consequences of teaching about cancer). Thus, the quality of the general statements drawn from belief scales should be determined by assessing the reliability of the scales [58], which is not possible using single item models [20,56]. The advantage is that more general statements about beliefs become possible, and thus, researchers are not required to consider all different aspects covered by the belief items that form a scale. However, researchers may encounter a situation in which they have to remove items from the scale due to low item discriminatory power [63]. When these items are removed from the scale and not considered further, using scale models is disadvantageous because the diversity of teachers' beliefs is not fully acknowledged [7].

In this study, we observed this issue particularly when beliefs describing many different aspects were merged into a scale (i.e., "control beliefs: external facilitators", $\alpha = 0.45$; "control beliefs: external inhibitors", $\alpha = 0.45$). If these aspects are assessed differently by teachers, the interitem correlation will be reduced, decreasing the reliability of the scale [12]. Therefore, Fishbein and Ajzen [15] and other authors applying the theory of planned behavior [53] argued that high levels of reliability cannot necessarily be expected in belief scales. Therefore, using scale models is disadvantageous if beliefs that cover many different aspects of the belief content are used and researchers intend to use reliable scales. One solution to this problem could be to develop new belief items that address similar aspects of the belief content as the items already aggregated in the scales. This method is particularly useful for scales that contain only a few items (i.e., "normative beliefs: irrelevant referents", which has three items) as having more items could help increase the reliability of a scale [82].

6.3. Implications for Planning Teacher-Training Interventions

Teacher-training interventions predicated on teachers' beliefs generally aim to strengthen favorable beliefs and weaken unfavorable beliefs [8], for example, by exposing teachers to new information that changes the teachers' beliefs. Single item models and belief scale models could be used for planning these interventions since both model variants allow researchers to identify favorable and unfavorable teachers' beliefs. Depending on whether single item models or scale models are used for intervention planning, there are different consequences for the design of the intervention [8,69].

Teacher-training interventions planned on the basis of the statistical analyses from single item models follow a design that aims to address the specific beliefs of teachers. For identifying the specific beliefs to be included in the intervention, the relative weight of the specific beliefs is used. The relative weight is typically indicated by standardized regression coefficients (β-values; see final columns in Tables 3–6) that emerged from the statistical analysis. The higher the relative weight of a specific belief (i.e., the higher the β-value), the more likely it is that changing this belief will influence teachers' attitudes, their perception of social pressure, and their perceived behavioral control to perform the behavior, thus affecting teachers' intention to perform the behavior and their behavior related to teaching and learning [8].

Regarding the planning of a teacher-training intervention for cancer education, the single item model helped us identify that teachers' attitudes towards the perceived necessity of teaching about cancer were determined by the belief that cancer education would increase student interest in biology. This belief should be strengthened in the context of an intervention because it positively contributes to the perceived necessity of teaching about cancer, which is a positive predictor of the teachers'

willingness to teach about cancer [62]. An intervention focused on this belief could address the fact that learners find certain types of cancer more interesting compared to others. Studies [83] have shown, for example, that learners assess leukemia, brain tumors or skin cancer as more interesting than colon cancer or gallbladder cancer. However, textbooks often address the latter types of cancer. The teacher training should therefore focus on how to integrate types of cancer into the biology classroom that attract student interest in order to strengthen student interest in biology.

In addition, the single item models helped us identify the causes of teachers' attitudes about the perceived burden of teaching about cancer. For example, the perceived burden was caused by the teachers' fear of their students' emotional reactions and their lack of content knowledge about cancer. This finding is relevant for designing a teacher-training intervention as it provides specific information regarding how to reduce the perceived burden (i.e., lowering the impact of beliefs that positively contribute to the perceived burden and strengthening the impact of beliefs that are negatively related to the perceived burden) [8,69]. For example, to address the belief that teachers fear their students' emotional reactions, an intervention can illustrate strategies on how to defuse emotionally charged situations in the classroom [84]. To increase teachers' content knowledge about cancer, teacher training could focus on the hallmarks of cancer [85] and introduce how they provide an opportunity to apply basic biology concepts in the field of genetics or cell biology [86,87].

An advantage of using single item models for designing teacher-training intervention is that they provide specific information regarding the relative weight of each individual belief, which eases the identification of the beliefs to be included in the intervention. However, researchers may also be faced with the result that several beliefs have similar relative weights and that the relative weight is considerable low. For intervention planning, there is a potential risk of considering nonrelevant aspects that will not lead to the intended changes in attitudes, social norms, and perceived behavioral control [8].

Teacher-training interventions planned on the basis of the statistical analyses from belief-scale models typically rely on statements to be made about the predictive power of groups of teachers' beliefs. When using scale models, one advantage in planning interventions is that the predictive power of two belief scales combining either positively or negatively evaluated beliefs can be easily compared. For example, we found that teachers' perceived autonomy to teach about cancer was significantly predicted by the scale "control beliefs: external facilitators" (ß = 0.496) but not by the scale "control beliefs: external inhibitors" (ß = 0.553, $p = 0.253$). These findings are of practical relevance for planning interventions. An intervention designed to increase teachers' sense of autonomy could be more promising if it addresses how external control factors might facilitate teaching about cancer than how external control factors might impede teaching about cancer. For example, an intervention could illustrate how teachers could use existing textbooks and other teaching materials in an appropriate way rather than to emphasize their inadequacies. The intervention therefore does not deal with the content of a specific teachers' belief (as illustrated for the single item models above), but instead addresses the common contexts of the aggregated beliefs.

Scale models can also be used to evaluate how well the aggregated beliefs fit the measures of attitudes, social norms, and perceived behavioral control [20]. For example, in the present study, the scale "behavioral beliefs: positive consequences" had a high predictive power for attitudes towards the perceived necessity of teaching about cancer (AB-N, $\beta = 0.596$) but not for attitudes towards the perceived burden of teaching about cancer (AB-B, $\beta = -0.131$). This result leads to the conclusion that the contexts summarized in the belief scale are less suitable for predicting attitudes towards the perceived burden than predicting attitudes towards the perceived necessity (even if some items of the scale have a high predictive power). Thus, an intervention aiming to modify attitudes towards the perceived burden of teaching about cancer is unlikely to succeed if it uses general statements about the positive consequences of cancer education. In contrast, it is necessary to consider the content of specific belief items (i.e., by using findings from single item models) to identify which specific beliefs can be used to reduce the burden of teaching about cancer.

7. Limitations

The data set in [62], used for the statistical analysis in the present paper, included imputations for one-third of the belief-based measures due to the application of a planned missing data study design [70]. This relatively high proportion of imputed data can negatively affect the parameter estimation of the structural equation models and model fit indices [71,88]. Although the model fit indices RMSEA and CFI are still acceptable for most models, the size of the χ^2 test statistic in relation to the complexity of the models (i.e., the ratio χ^2/df—an established criterion for assessing the model fit [79]) is well above the desired ratio of $\chi^2/df < 3$ in all model variants. Thus, the model-implied variance-covariance matrix does not accurately represent the true relationships between the variables [12]. Therefore, the results of the study should be interpreted with caution. One possible explanation for this finding is that the items used to measure beliefs did not correspond to the actual beliefs of the sampled teachers [15]. To correct these misspecifications, adjustments were made by specifying the correlations between the residual variances [89]. However, this procedure represents a "data-driven model building strategy" [74] (p. 164). Since no cross-validation was carried out, the procedure entails the risk that sample-dependent changes were made, which could limit the scope of the conclusions.

8. Conclusions

In the present study, we compared belief-based measures in the context of the theory of planned behavior through single item models and scale models. For this purpose, we combined two questionnaires addressing belief-based measures and direct measures of attitudes, social norms, and perceived behavioral control and formed belief scales by using the EVP, as suggested in [7].

The discussion of the findings revealed that both procedures (i.e., using single item models and scale models) have specific advantages and disadvantages. Both model variants result in similar conclusions that do not contradict each other. However, the two models vary in how these conclusions are reached. For example, regarding behavioral beliefs, the statistical analysis yielded the result that the positive consequences of teaching about cancer strongly predicted teachers' attitudes. In the context of a behavioral-belief-based intervention, researchers could either specifically address the single, positive consequences of teaching about cancer that were identified through the single item model or use more general statements about the positive consequences of teaching about cancer as suggested by the scale model.

For researchers interested in applying the theory of planned behavior in the planning of belief-based interventions, the findings of the present study recommend combining the advantages of single item models and scale models. If reliable scales can be formed, researchers should use such scales since they allow for more general statements, and reliability can be tested. Furthermore, the formation of scales is consistent with the standards of psychological testing [21,54,59,82]. However, if it is impossible to rely on reliable belief scales or the belief scales are not significant predictors, researchers should use single item models to gain precise insight into the individual beliefs determining the formation of attitudes, social norms, and perceived behavioral control.

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