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Development and validation of a text-based instrument measuring teachers' professional vision of student thinking

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Abstract

Accurate teacher judgments of student thinking are key to adaptive teaching. Yet, making such judgments represents a particularly challenging task for teachers. Developing instruments that can elicit and capture teachers' cognitive processes of noticing and interpreting is essential for assessing their skills. These instruments should be sensitive to the teachers' cognitive processes and specific qualities of student thinking in the respective domain. In this article, we present an approach to develop and validate a text-based vignette test which meets these requirements. We used the example of teachers' noticing and interpreting of cognitive aspects in learners' attitudes on creation and evolution. We identified relevant components of student thinking in this domain and included these components systematically varied in written classroom vignettes. Experts confirmed a clear and salient representation of the components of student thinking that we intended to include.

Keywords

professional vision; teacher judgments; student thinking; vignette test; validation

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1 Introduction

Accurate teacher judgments of student thinking provide the basis for adaptive teaching (Hardy et al., 2022). Understanding how teachers arrive at their judgments is crucial for fostering their judgments of student thinking (Loibl et al., 2020). Therefore, it was our goal to develop an instrument that captures teachers' diagnostic processes that lead to their judgments of student thinking. The diagnostic processes leading to teacher judgments during classroom interaction have been described as noticing and interpreting student thinking, for example, in research on teachers' professional vision (Farrell et al., 2022) and teachers' on-the-fly assessment (Hoppe et al., 2024).[1] Teachers' noticing and interpreting of student thinking depends not only on, for example, teachers' professional knowledge, these diagnostic processes also depend on specific properties that emanate from student thinking as the target of teachers' judgments (Hoppe et al., 2024; Oudman et al., 2023). Teachers often need to notice and interpret various components of student thinking and relate them to each other to draw valid conclusions (Oudman et al., 2023). In our study, we use the example of students' attitudes on evolution and creation. These attitudes consist of different components that are interrelated (Konnemann et al., 2016). For example, to generate plausible explanations of why students reject evolutionary theory, teachers need to consider further components of students thinking that have explanatory value. In this case, students may adhere to beliefs compatible with creationist thinking which prompts them to reject evolutionary theory.

Opportunities to notice and interpret student thinking, which comprises different components, can basically occur across all school subjects and knowledge domains. In either case, teachers need to be able to notice and interpret different components of student thinking and relate them to each other to draw inferences which can inform further instruction. However, noticing and interpreting student thinking with the goal of adaptive teaching represent challenging tasks even for experienced teachers (Hoppe et al., 2020b). Several studies have shown that pre-service teachers benefit from practice-based, specific trainings that foster their professional vision (e.g., Codreanu et al., 2022; Martin et al., 2023). Assessing and developing teachers' noticing and interpreting of student thinking then requires instruments that are sensitive to teachers' diagnostic processes when making judgments (i.e., noticing and interpreting relevant student information) and specific characteristics of student thinking (e.g., different components varying in explanatory value or diagnosticity) (Oudman et al., 2023). In this article, we introduce an approach for developing and validating a text-based instrument that meets both requirements. The methodological focus of the research presented here is on the validation of the instrument because this aspect is often overlooked in the development process (Weyers et al., 2023).

When developing a text-based instrument to assess teachers' professional vision, we first analyzed the different components of student thinking that typically constitute student attitude profiles on evolution and creation. Then we created classroom vignettes that systematically represented these components of student thinking in students' statements. In a validation process, we ensured clear and salient representation of the intended components of student thinking as well as perceived authenticity of the classroom vignettes. The

[1] In this article, when referring to both noticing and interpreting student thinking we use the term professional vision bearing in mind the conceptual overlap with, for example, teachers' on-the-fly assessment.

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theoretical considerations underlying the vignette development, as well as the aspects particularly relevant for validation, are outlined in the following sections.

1.1 Analysis of target content: The nature of student attitudes and its implications for teachers' diagnostic processes

Given the very different possible manifestations of student thinking, the development of an instrument assessing and fostering teachers' professional vision benefits from careful analysis of specific, typical characteristics in student thinking to be noticed and interpreted. In our study, we focused on cognitive aspects in student attitudes on creation and evolution as types of student thinking. Attitudes are regarded as multicomponent evaluations that are relatively consistent (Konnemann et al., 2016). Students' attitudes on evolution and creation represent an essential learning prerequisite in the teaching of evolution and biodiversity, as well as scientific literacy and in religious education (e.g., Yasri & Mancy, 2016). Extensive quantitative and qualitative research has been conducted on student attitudes towards evolution and creation (Höger, 2020; Klose, 2014; Konnemann et al., 2016). Konnemann et al. (2016) identified diverse attitude profiles among secondary school students comprising different components. Among other dimensions, these components in student attitude profiles include students' positive or negative evaluations of evolution and creation as well as the presence or absence of scientistic or creationist beliefs.

When components of student thinking differ in their explanatory value, they differ in their diagnosticity, which in this context might convey more or less relevant information for a full understanding of students' thinking and thus for guiding further instruction (Oudman et al., 2023). For example, teachers might notice that students are expressing a negative evaluation of evolution, for example, by rejecting the theory of evolution. This observation might then prompt teachers to support students to develop a more positive evaluation of evolutionary theory. To be able to support the students, teachers need to be informed about the reasons for students' negative attitudes towards evolution. Studies have shown that the rejection of evolutionary theory can be related to beliefs that are compatible with creationist thinking (Konnemann et al., 2016). When students express beliefs that are compatible with creationist thinking, they often assume that the biblical stories of creation are to be understood as accounts of natural history. When teachers assess whether students hold on to creationist thinking, teachers can make instructional decisions tailored to the students' needs. For example, when reacting to students that express creationist beliefs, teachers can emphasize that evolution and creation represent two different modes of encountering the world and are not necessarily in conflict with each other (Rothgangel, 2019). Differentiating between evolution and creation in this manner could help students develop more positive attitudes towards evolutionary theory. The example chosen here shows that while students' rejection of evolutionary theory can prompt a teacher's intervention, teacher judgments on students' creationist beliefs are particularly diagnostic because in this case these beliefs are crucial for sufficiently informed instructional decisions (Oudman, 2023).

1.2 Analysis of teachers' diagnostic processes of noticing and interpreting

Teachers' cognitive processes that lead to judgments on student thinking are addressed in largely overlapping constructs in teacher education research, for example, teachers' professional vision, teacher noticing, and on-the-fly assessment. In these contexts, the two diagnostic processes of noticing and interpreting are frequently used. In teacher education

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research, the term “noticing” also increasingly includes interpreting (van Es & Sherin, 2021). However, Seidel (2022) argued that from a cognitive psychological perspective, the two processes should be differentiated so that teachers’ learning processes can be clarified more precisely, and possibilities for support within teacher training can be examined more specifically. Consequently, instruments for assessing teachers’ diagnostic processes ideally address both noticing and interpreting. Noticing describes teachers’ selective attention to relevant events for teaching and learning (Farrell et al., 2022). Interpreting describes the process of teachers making sense of what has been noticed (Farrell et al., 2022). The process of interpreting is also described as knowledge-based reasoning because teachers ideally apply relevant professional knowledge when interpreting student thinking (Farrell et al., 2022).

When noticing and interpreting student attitudes, these processes can be assessed on two levels. First, the question arises whether teachers notice when students make statements indicating their attitudes apart from everything else happening during classroom interaction (e.g., student statements indicating errors in student thinking) and whether teachers interpret them as such. Second, the question arises whether teachers notice different components in student statements that constitute student attitudes and how teachers interpret these components. Conclusively, instruments that capture teachers’ diagnostic processes of noticing and interpreting should measure these processes at different levels. To assess teachers’ noticing, instruments should represent relevant variants of student thinking (i.e., student attitudes) among other variants of student thinking (i.e., student errors) to evaluate the extent that teachers notice a certain variant of student thinking. Furthermore, to evaluate teachers’ interpretations of what they have noticed, components of student thinking, including cues with varying diagnosticity, should be assessed.

1.3 Selection of an adequate vignette format

Video and text vignettes have been used to assess and foster teachers’ diagnostic processes of noticing and interpreting (Codreanu et al., 2022; Kramer et al., 2020), which allow for situated assessment of these processes because of their similarity to classroom practices. Comparative studies have shown that the use of both media formats are similarly effective (e.g., Hoppe et al., 2024; Schneider et al., 2016). As artefacts, scripted videos enable a precise fit between diagnostic processes and relevant target content (Seidel et al., 2021). Video vignettes are considered particularly authentic because they represent many facets of “real” classroom practices (Grossman et al., 2009). However, these many facets might also impede representation and systematic variation of very specific student cues in experimental settings because of the likely occurrence of confounding variables. Text vignettes might appear less authentic than video vignettes, yet they allow for better control of cue representation and variation. Given the need for a precise representation of very specific student cues when assessing complex aspects in student thinking, we chose text as a format for vignette production.

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1.4 Selection of evidence-based content and representation of student cues in classroom vignettes

To identify the evidence-based components that constitute student attitudes towards evolution and creation, we referred to the multi-dimensional conceptualization from the study of Konnemann et al. (2016). The main components of student attitude profiles identified by Konnemann were also evident in the data conducted in a qualitative longitudinal study by Höger (2020). For the development of the instrument, we chose student attitude profiles representing scientistic and creationist positions. These profiles are particularly relevant for adaptive teaching given the assumption of conflict between science and religion. We further included nonscientistic and noncreationist attitude profiles as counterparts. To produce authentic classroom vignettes, we used interview data from this qualitative study. Following analyses by Höger (2020), we identified student statements that represent specific cues (e.g., positive evaluation of evolutionary theory), and then we used these statements to create short classroom sequences. By using original student statements, we aimed to establish authenticity, which is an important criterion to ensure ecological validity of the vignettes and participants' motivation (Seidel et al., 2022).

The following example illustrates how different statements by a student representing relevant student cues have been transformed into a small classroom sequence. The student displayed in the sequence represents a creationist attitude profile (Konnemann et al., 2016).

Annika:	I can't imagine that humans just came into being through evolution. We have learned that there were once bacteria, only bacteria, and then that changed. At some point, animals… um… came into being and then humans. But I can't imagine that. I don't believe that.
You as the teacher ask what Annika thinks, how humans came into being.	
Annika:	I think that God has something to do with it. It's also in the Bible. Adam and Eve. Mhm, yes, they are actually our… um… how do you say it? Relatives. Ancestors.

Fig. 1: Example of representation of student cues in classroom vignettes

Note. The following student cues are represented in the vignette: negative attitudes towards evolutionary theory (AE-); positive attitudes towards faith in creation (AC+); beliefs compatible with creationist thought (CR)

1.5 Structure of the vignette test and question format

Based on the previously presented theoretical and conceptual considerations, the following vignette types were constructed. We constructed a vignette with a focus on teachers' noticing to assess the extent that teachers consider students' attitudes as relevant for further teaching and learning apart from other student statements, and we constructed vignettes with a focus on teachers' interpreting to assess how teachers make sense of students' attitudes. Open question formats allow to determine different competence levels of noticing and interpreting

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skills (Brovelli et al., 2014).Table 1 shows the target diagnostic process (noticing or interpreting), the content of the vignettes, and the open questions. The vignette for measuring teachers' noticing (vignette 1) allows to assess whether participants select situations that allow for the interpretation of student attitudes apart from other important situations in the classroom, for example, when students express misconceptions about evolution. Therefore, students' misconceptions represented in the vignette serve to distract from students' attitudes when teachers observe the classroom situation. The vignettes for measuring and fostering teachers' interpretation of student attitudes (vignettes 2 & 3) each contain three different attitude profiles. In each vignette two of these attitude profiles depict profiles that are regarded as problematic from a subject-matter education perspective ("creationist" and "scientistic" profiles). The third profile includes no student cues that are generally regarded as problematic. These vignettes were produced in double versions so that it can be determined whether teachers can assess profiles consistently. Weyers et al. (2023) found that the aspect of validation is often overlooked when developing instruments to assess teachers' professional vision. Following the construction of vignettes based on theoretical considerations, we subjected these vignettes to a validation process.

Table 1. Overview on vignette construction types regarding target diagnostic processes, content of the classroom situations and open questions.

Vignettes and target diagnostic process	Content	Open questions
Type 1 (vignette 1) Noticing	Student misconceptions and student attitudes	1. What do you notice that would be important for the students' further learning? Please give reasons. 2. What else do you notice?
Type 2 (vignettes 2 & 3) Interpreting	Student attitudes (3 different profiles)	How do you assess the attitudes of the individual students towards the topic of creation and evolution? Please give reasons for your assessment for each student, if possible.

1.6 Aim of study (RQ)

Our goal was to develop and validate a text-based instrument measuring teachers' professional vision that is sensitive to teachers' diagnostic processes and specific characteristics of student thinking. Our aim was to ensure that student cues would be sufficiently salient and unambiguous in the presentation of materials. The presented classroom situations should be perceived by participants as authentic, and it must be possible for conclusions to be drawn about their diagnostic processes. Based on our goal, theoretical considerations and the procedure in developing the instrument, we arrived at the following research questions:

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1) Representation of student cues

(a) Do student cues in the vignettes depict the intended content constructs according to expert judgments?

(b) Are these student cues presented in a sufficiently salient manner according to expert judgments?

2) Authenticity of the text-based vignettes

(a) Do teachers generally perceive the vignettes as authentic representations of practice?

(b) Do teachers from both relevant school subjects (i.e., biology education and religious education) equally perceive the vignettes as authentic?

3) Inferences on teachers' noticing and interpreting

What kind of teacher observations can be elicited using the text-based vignettes in combination with an open question format?

2 Method

2.1 Sample

To determine whether the relevant content constructs are clear and sufficiently salient in their representation as student cues, we used data from university lecturers and researchers. We selected university lecturers and researchers who were considered experts in the field of teaching and learning at the intersection of science and religion. We included data from $n = 5$ lecturers/researchers with a focus on religious education (RE), and $n = 5$ lecturers/researchers with a focus on biology education (BE). The selected lecturers/researchers belong to seven different universities in Germany. To assess perceived authenticity of the vignettes, we included data from in-service teachers ($N = 11$; RE: $n = 5$, BE: $n = 5$, RE and BE: $n = 1$). All in-service teachers taught at secondary schools in Freiburg, Germany. All data were collected via questionnaires. We included data from $N = 17$ biology education teacher students from the University of Education Freiburg (female: 82.35%) to evaluate how the diagnostic processes of noticing and interpreting can be assessed using the text-based vignettes combined with an open question format. All students were enrolled in the university's master's program.

2.2 Procedure

All participants were contacted via email and were asked whether they would participate and respond to the measures of student cue representation and perceived authenticity of the text-based vignettes. Data were anonymized after the dataset was made available to us. We used questionnaires that could be completed either using paper and pencil or digital tools, depending on participants' preferences. Data collection for the measurement of teacher education students' noticing and interpreting was administered only via online software. The data collection was integrated into an online seminar on biology didactics.

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2.3 Measures

2.3.1 Clear and salient representation of student cues

To measure adequate representation of cues in the vignettes, we developed a scale consisting of four items (see Table 2). Adequate representation of each relevant student cue in the two main vignettes was rated by participants on a 5-point scale.

Table 2. Excerpt from the scale for representation of student cues

Student: Annika	clearly negative	rather negative	neutral	rather positive	clearly positive
Attitudes towards evolutionary theory	□	□	□	□	□
Attitudes towards faith in creation	□	□	□	□	□
	clearly no	rather no	ambi-valent	rather yes	clearly yes
Creationist beliefs	□	□	□	□	□
Scientistic beliefs	□	□	□	□	□

Note. Participants assessed whether the representation of the four different student cues (left column) in the vignette were sufficiently salient. Participants assessed representation of these cues for a total of six student profiles. The intended profiles were not revealed to the participants.

2.3.2 Authenticity of classroom vignettes

We used a 5-point scale consisting of three items (Table 3) that we adapted from Codreanu et al. (2020) to capture the extent to which the written classroom situations in the vignettes were perceived as authentic representations of practice.

Table 3. Scale for authenticity: Number of items (N) and items.

Scale	*N*	Items
Authenticity of vignettes	3	I think the written classroom situation is authentic.
		The written classroom situation comes across like a real-life classroom situation.
		The experience of the written classroom situation was similar to the experience of a real-life classroom situation.

Note. Likert response scale from 0 (does not apply) to 4 (applies)

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2.3.3 Evaluation of noticing and interpreting

To elicit teachers' noticing and interpreting, we used an open question format suitable for assessing various competence levels in the participants' observations (e.g., Kersting, 2008). To describe participants' observations, we developed a coding scheme based on the categories of teacher professional vision (Farrell et al., 2022). Thus, we aimed for a reconstruction of participants' cognitive processes of noticing and interpreting based on the written data. To assess the extent that participants noticed students' attitudes, we assessed whether they addressed student statements that indicated underlying attitudes in their written observations of the first vignette (see Table 1), which included not only referring to student errors, for example, but also expressions of attitudes (e.g., a negative evaluation of the theory of evolution or scientistic beliefs). We also assessed the extent that participants referred to diagnostic cues when evaluating students' attitudes towards creation and evolution based on observations in vignettes 2 and 3. Diagnostic cues are student statements that have explanatory value for understanding student thinking. We further assessed the extent that participants' interpretations of diagnostic cues were knowledge-based or uninformed (Farrell et al., 2022). Knowledge-based interpretations are informed by professional knowledge in the sense that participants' responses explained students' positive or negative attitudes connecting to theoretical or vignette-based evidence (Farrell et al., 2022). For example, participants infer creationist beliefs from a negative evaluation of the theory of evolution, a positive evaluation of belief in creation and a literal understanding of the biblical creation stories. Uninformed interpretations are characterized by participants' assumptions about explanations of student attitudes that were not connected to theoretical- or vignette-based evidence. For example, participants wrongly infer a negative evaluation of belief in creation from merely a positive evaluation of the theory of evolution, thereby ruling out the possibility of a balanced student attitude profile.

3 Results

3.1 Clear and salient representation of student cues

Descriptive statistics were computed to describe the extent that participants evaluated the representation of student cues for the six key student profiles in the vignette test. Values ranged from 1 = lowest to 5 = highest value (see Table 4). Vignette 1 was not included in this validation step because it was conceptualized with a different focus (see Table 1). When student cues were intended to be present in the vignette, higher mean values show that experts rated these cues as sufficiently represented. When student cues were intended to be absent in the vignette, lower mean values show that experts found that these cues were not represented in the vignette. Results reveal that the experts' assessments for the student profiles in vignettes 2 and 3 were largely in line with the categories we had intended. Thus, experts confirmed a clear representation of all student cues and conclusively a salient representation of the different student profiles. Overall, very good agreement between raters was measured (*ICC* = .983).

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Table 4. Descriptive statistics for representation of student cues (Vignettes 2 [V2] and 3 [V3]): Mean values *(M)*, and standard deviation *(SD)*.

Creationist profile (V2)		Scientistic profile (V2)		Conciliatory profile (V2)	
Cues	*M (SD)*	Cues	*M (SD)*	Cues	*M (SD)*
AE-	1,74 (0,46)	AE+	4,88 (0,35)	AE+	4,75 (0,46)
AC+	4,88 (0,35)	AC-	1,13 (0,35)	AC-	2,38 (0,52)
CR+	4,13 (0,99)	CR-	1,00 (0,00)	CR-	1,29 (0,49)
SC-	1,17 (0,41)	SC+	4,38 (1,06)	SC-	2,13 (1,36)
Creationist profile (V3)		Scientistic profile (V3)		Balanced profile (V3)	
AE-	1,25 (0,46)	AE+	5,00 (0,00)	AE+	4,75 (0,46)
AC+	4,86 (0,38)	AC-	1,00 (0,00)	AC+	4,50 (0,54)
CR+	4,75 (0,46)	CR-	1,00 (0,00)	CR-	1,71 (0,95)
SC-	1,00 (0,00)	SC+	4,57 (0,79)	SC-	1,29 (0,49)

Note. +/- mark the level of cue expression as intended by the authors. AE +/- = positive or negative attitudes towards evolution, AC +/- = positive or negative attitudes towards creation, CR +/- = presence or absence of creationist beliefs, SC +/- = presence of absence of scientistic beliefs. A 5-point scale was used. Low values indicate low level of positive or negative attitudes towards creation or evolution (AE, AC) or an absence of student cues (CR, SC), high values indicate a high level of positive or negative attitudes (AE, AC) or the presence of certain student cues (CR, SC). Each vignette represented three student profiles.

3.2 Authenticity of classroom vignettes

Descriptive statistics were computed for each vignette to describe how participants assessed authenticity of the text vignettes. On average, the participants rated the authenticity of the vignettes in the upper half of the Likert response scale (see Table 5). Mann-Whitney U tests indicated that perception of authenticity between in-service teachers of Biology Education and in-service teachers of Religious Education were not significantly different (see Table 6).

Table 5. Descriptive statistics for authenticity: Mean values (M), and standard deviation (SD).

Scales	*M*	*SD*
Authenticity of text vignette (0)	2.36	0.82
Authenticity of text vignette (1)	3.21	0.56
Authenticity of text vignette (2)	2.64	0.82

Note. N = 11. Likert response scale between 0 (does not apply) and 4 (applies).

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Table 6. Results of the Mann-Whitney U tests to examine the influence of the subject taught (Biology Education or Religious Education) on the rating of authenticity.

Vignette	*U*	*Z*	*p*
1	88,500	-1,092	0,275
2	69,000	-2,115	0,064
3	90,000	-1,020	0,308

Note. *n* = 5 Biology Education teachers, *n* = 5 Religious Education teachers

3.3 Assessment of pre-service teachers' noticing and interpreting

Based on the participants' written observations, we were able to ascertain the extent that pre-service teachers noticed students' attitudes. In some observations, participants referred to students' statements hinting at underlying attitudes, for example, when noting that "Clara has doubts concerning evolution" (CASE139). Other participants noticed students' attitudes but focused on student errors presented in the classroom vignettes, for example, when outlining students' alternative conceptions ("Dennis has the idea that the giraffes got a longer neck because they need it → purpose to get food", CASE163). We were able to distinguish different qualities of pre-service teachers' interpretation of student statements indicating underlying attitudes. We first coded whether participants referred to cues with a higher degree of diagnosticity. For example, the statement, "Annika holds on to the belief in creation, the theory of evolution is improbable for her" (CASE021), indicates reference to cues presented in the vignette (positive attitude towards creation, negative attitude towards evolution), whereas the more diagnostic cue (creationist beliefs) was not noticed and interpreted.

If diagnostic cues had been noticed, we assessed the adequacy of participants' interpretations concerning the application of relevant professional knowledge. Adequate interpretations are characterized by participants' descriptions of the extent to which students seem to understand the limits and scope of evolutionary theory or faith in creation. These descriptions represent professional knowledge, which may be applied when interpreting student attitudes. Such a description can be illustrated by the following statement: "Annika holds a creationist view of creation and evolution. She possibly considers the creation story to be a factual account. […]" (CASE179) The participant infers creationist beliefs from the students' statements, which are likely to explain the students' negative attitude towards evolutionary theory. Other participants applied no relevant professional knowledge when interpreting diagnostic cues as illustrated by the following example: "Annika seems to be very religious and is more convinced of creation. For her, evolution doesn't sound plausible; she finds it more believable that all humans are descended from Adam and Eve." (CASE134). Rather than referring to the limits and scope of science and theology, the participant inferred a particularly strong conviction of religious faith, explaining the students' negative attitudes towards evolution and positive attitudes towards creation. Such interpretations can be labelled as uninformed by professional knowledge (Farrell et al., 2022). The juxtaposition of conflict and non-conflict profiles in the vignettes allows to identify judgment errors in the interpretation of students' attitude profiles. For example, a student representing a non-conflict view was judged to be less convinced of evolutionary theory than a student representing a conflicted

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view [“Amir believes in the theory of evolution but is not yet as precise as Marco, who had already fully studied the subject and has a clear and definite conviction.” (CASE038)].

4 Discussion

We outlined the development and validation of text-based classroom vignettes representing student statements that hint at underlying student attitudes. The cognitive aspects of student attitudes can be viewed as examples of student thinking, which comprises several different components. The vignettes were developed to assess and foster pre-service teachers’ professional vision. In developing the vignettes, we first analyzed the different components that constitute student attitude profiles about evolution and creation. We scrutinized the diagnosticity of different cues (e.g., cues with more or less explanative value), and how these cues interact with each other (e.g., inferences that can be drawn between cues). Then, we selected original student statements that represented student profiles of didactical relevance and transferred these statements into short classroom sequences. Each student attitude profile was depicted by the presentation of different, previously defined student cues. With the help of experts, we ensured clear and salient representation of student cues as well as perceived authenticity of the classroom vignettes as representations of practice. We conclude that the vignettes are promising, valid instruments for assessing in-service teachers’ assessment of noticing and interpreting of student thinking.

For the assessment of teachers’ professional vision of student thinking, we suggest an open question format which is suitable to measure different competence levels (Brovelli et al., 2014). To assess pre-service teachers’ professional vision, we separate the diagnostic processes of noticing and interpreting, even though these processes are intertwined. If no process data are collected, the diagnostic processes of noticing and interpreting must be inferred retrospectively from the participants’ observations. This practice leads to some limitations, yet it has also proven to be a common and beneficial procedure in the assessment of teachers’ professional vision (e.g., Hoppe et al., 2020a). In other studies, process data can be collected, for example, via eye-tracking (Gegenfurtner et al., 2011). Yet, the question arises as to whether the expected insights justify the expense. In the current study, we expected that participants’ observations would likely reveal whether they noticed student attitudes as a construct and diagnostic cues as indicative of certain attitude profiles. With regard to the participants’ interpretative performance, we were able to infer whether the interpretation of these diagnostic cues had been informed by adequate professional knowledge. Furthermore, identifying precisely when participants need support in developing their interpreting skills is possible, for example, when important aspects in students’ statements (diagnostic cues) are not considered in the interpretation, when judgment errors distort participants’ interpretations, or when participants lack professional knowledge to adequately interpret student cues they have noticed.

We propose that our approach of developing a text-based instrument that assesses teachers’ professional vision can serve as a model. The proposed procedure is particularly fruitful for identifying different interrelated components of student thinking that can help teachers form appropriate judgments in the context of their professional vision. This procedure can be generalized across different school subjects and topics. The different components of student thinking can be presented and systematically varied as different student cues. Presentation of these cues can then elicit teachers’ professional vision. Even though we focused on the

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assessment of teachers' professional vision when developing the vignette test, such instruments can be used to directly foster teachers' professional vision as well (Hoppe et al., 2024).

As a limitation of our study, we acknowledge that our calculations for the assessment of authenticity lack power given that even though all raters were very well suited for the field of assessment, they were small in number. In this respect, the results of the expert ratings should be interpreted with caution. In view of the vignettes' utility in experiments as well as the general feasibility of vignette development, we chose a text format for the vignettes. Despite its advantages, text vignettes cannot authentically represent the volatility of the real classroom situation (Chan, Xu et al., 2020). However, we assume that in line with our research goals, accepting a certain degree of inauthenticity of texts as opposed to video is an expedient solution. We also realize that the vignettes presented in this study essentially show ideal states of student thinking given that all relevant components are represented. In actual classroom situations, student thinking may be conveyed less clear or less complete in student statements. Such variants of student thinking can, in principle, also be mapped as student cues, as we have proposed, to assess and foster teachers' professional vision.

Despite the limitations we showed that text-based vignettes that clearly depict specific constructs in student thinking conceptualized as student cues with varying diagnosticity can be developed. These text-based vignettes had been perceived as authentic by in-service teachers. Using these vignettes in combination with an open question format, we elicited sufficient pre-service teachers' observations to be able to retrospectively reconstruct their cognitive processes of noticing and interpreting. These criteria make the vignettes suitable for not only assessing teachers' noticing and interpreting skills but also fostering their professional vision through implementation in respective interventions.

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Appendices

Vignette 1 (Focus on teachers' noticing of students' attitudes)

You have planned a lesson titled "Origin and Development of the Earth and Life." The class is currently working on a task about the evolutionary biological explanation of the change in traits. This task describes that the ancestors of today's giraffes had significantly shorter necks. The students are then asked how they imagine the evolution of giraffe necks.

Laura: It was survival-related because they had, I don't know, I somehow heard or read this somewhere, I don't remember… They fed on some tree. To reach those leaves that they liked, they didn't need a short neck.

You ask Laura to explain how she imagines this process.

Laura: To get their food, they ended up with a longer neck.

Paul and Jasmin raise their hands. You ask both of them how they imagine the evolution of giraffe necks.

Jasmin: Well, yes, I think it's like what Laura said. But not all at once. A long time ago, they had short necks like, um… a horse or something. I think it happened bit by bit, maybe millimeter by millimeter.

Paul: I also think it happened bit by bit. Maybe one animal had a genetic defect and had a longer neck than the others, and this genetic defect might have become more common, and so it kept going.

Jasmin: Yes, exactly.

Paul: Although I find evolution… well, in principle, I find it all pretty hard to believe. Sure, many things have changed in evolution. But with these ape-human things and all, I can't imagine it. That God created the world and had something to do with how humans came into existence, I also doubt that.

Jasmin: (*laughs*) Well, humans did have millions of years to evolve until they looked the way they do today.

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Vignette 2 (Focus on teachers' interpreting of students' attitudes)

Imagine you are teaching a 9th-grade class. In a previous lesson, the students studied the human family tree. You see Annika shaking her head and ask this student if she has something to share.

Annika: I can't imagine that humans just came into being through evolution. We learned that there were once bacteria, only bacteria, and then that changed. At some point, animals… um… came into being and then humans. But I can't imagine that. I don't believe it.

You as the teacher ask what Annika thinks, how humans came into being.

Annika: I think that God has something to do with it. It's also in the Bible. Adam and Eve. Mhm, yes, they are actually our… um… how do you say it? Relatives. Ancestors.

You notice Amir and Marco gesturing. When you look over at them, Amir raises his hand.

Amir: Well, you can kind of believe in both… in evolution and in God. And find reasons for both. But I personally don't believe that a god had anything to do with how humans came to be. I think that single-celled organisms lived on this planet and then… they developed further into humans.

Marco: Yes, I definitely see it that way too… with evolution. Life appeared on Earth at some point, and living beings then kept changing.

Amir: There has been a lot of research, and I think that science can't explain everything but can explain a lot.

Marco: And God… I don't believe in God and that he did anything. Because there are now enough scientific theories that prove that humans came about without God. And I just follow the scientific path and say: I haven't seen God, so he doesn't exist.

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