

Article

Identifying Student Teachers' Inquiry-Related Questions in Biology Lessons

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Abstract: Prior research has shown that both teacher-led and recitation questions dominate in classrooms; teachers ask closed-ended questions more than open-ended questions. Even though classroom questioning has been studied in many previous studies there has been very limited research addressing the questioning of student teachers during inquiry-based biology lessons focusing on the inquiry stages: introduction, examination, and conclusion. In this study, a total of 21 lessons by 12 student teachers in primary and secondary schools were video- and audio-recorded. The recorded discussions were transcribed and the qualities of the questions were analyzed using content analysis, and the questions of student teachers were categorized into 10 different question categories. The findings revealed that primary school student teachers asked mainly for factual knowledge, concepts, and basic knowledge of species in all inquiry stages. Secondary school student teachers also asked mainly for concepts and basic knowledge of species. They also asked students to generate ideas and explain their answers, especially in the examination and conclusion stages. The present study indicates that student teachers' questioning needs to be developed more towards higher-order questioning such as analyzing, synthesizing, and evaluating to scaffold students in inquiries and develop future teachers' questioning skills in teacher education.

Keywords: inquiry-based lesson; primary school; secondary school; student teacher questioning; teacher education



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1. Introduction

Teachers' questions are an important part of classroom talk; questioning plays an important role in determining the discourse during inquiry. Most classroom questions are asked by teachers [1–4]. Teachers' basic questions, such as factual and revision questions, dominate in classrooms [5–8]. Moreover, teachers often ask closed-ended questions [9,10], task-oriented questions [11], and questions requesting remembering and understanding, but fewer questions focusing on analyzing, applying, or creating [12,13]. Myhill and Dunkin [14] have emphasized that teachers use classroom questioning more for supporting and controlling their own teaching than enhancing students' learning. In particular, student teachers may either ask inappropriate questions or presuppose that students know the answer [15]. We are interested in how student teachers ask questions particularly in inquiry-based biology lessons.

Teachers' appropriate questioning supports students' learning processes. Authoritatively oriented questioning may not support but may dramatically limit students' opportunities to demonstrate higher order scientific understanding [16]. Dialogically oriented questions, in contrast, often grant students to demonstrate more both canonical and self-generated knowledge [16]. Even expert teachers experience challenges in developing more complex practices in the classroom particularly in applying open inquiries [17].

Even though questioning is a rather difficult task, teachers can develop their questioning skills in their teaching. Chin [18] has presented three factors influencing teachers' questioning skills. First, the teacher needs a good understanding of the subject matter so

that he/she can ask the appropriate questions to support students to integrate different concepts into a broader framework rather than experience them as isolated facts. Second, he/she needs pedagogical skills in crafting and sequencing the appropriate questions that progressively build on previous ones. Third, to teach using questioning sequences, the teacher needs also to be able to motivate students to co-operate with him/her instead of being passive recipients. To develop their questioning skills teachers could, for example, record teaching sessions and analyze the various interactions in the session involving questioning and follow-up, critique the interactions from an epistemological and pedagogical point of view, and finally reflect on alternative modes of interaction [19].

Scholars have reported different development programs to develop teachers' questioning skills. For example, secondary mathematics teachers' knowledge and skills of questioning changed when they implemented a cyclical process of planning, implementing, and reflecting on model-eliciting activities in their classrooms [20]. Teachers' ability to ask qualitatively different questions in order to move students' thinking forward developed [20]. In another study by Dekker-Groen, Van der Schaaf, and Stokking [21], the trained teachers used more deep reasoning questions and prompt responses, which potentially stimulate students to elaborate and reflect. When increasing awareness of social aspects of teacher questioning, teachers' referential questions (oral queries aimed at encouraging students to articulate their own ideas, understandings, experiences, and personal opinions) were twice as frequent after the practice as they were before it [22]. As teachers used constructivist teaching-practices, they asked significantly more questions and used significantly more open-ended questions compared with other types of questions, such as closed-ended questions and task-oriented questions [23].

Further, in the context of science education, several teachers' practices have been found to develop teachers' questioning skills. Biology teachers experienced the change in their ability to ask better inquiry questions during a laboratory course in microbiology when the laboratory techniques were presented in an explicit and generalized manner, in the context of specific research questions [24]. Generic questions that are derived from perspectives (ways of looking at and thinking about life processes) help in generating specific questions [25]. When biology student teachers were asked to individually generate as many questions as possible that they may ask on a particular biological topic; first without using, and then using, a set of perspective-based generic questions. It was found that, using perspective-based generic questions, student teachers generated significantly more and higher quality questions [25]. In a study of Lin, Hong, Yang, and Lee [26], teaching practices of science teachers revealed that teachers asked more high-level questions requiring students to identify researchable questions, make hypotheses, design investigation procedures, or provide evidence-based conclusions. Pedrosa-de-Jesus, Moreira, Lopes, and Watts [27] studied the nature and development of critical questioning. They emphasize that critical questioning relates to critical inquiry; critical questioners investigate problems, ask probing questions, pose new answers that challenge, and generate new information. The model used in questions-focused action research, both supported and motivated teachers to cultivate more effective questioning practices, leading to enhanced student engagement and learning [28].

Despite many studies highlighting the need for training teachers in questioning, research has focused mainly on mathematics [29–32] and chemistry classrooms [6]. In addition, students' competences to question have been widely studied [33–38]. In this study, we are interested in inquiry-based lessons cf. [24]. Inquiry-based education engages students in the learning process and is more likely to increase conceptual understanding than are strategies that rely on more passive techniques [39,40]. This study aims to provide new insights into primary and secondary school student teachers' questioning, particularly in inquiry-based biology lessons.

1.1. Interaction through Questioning in Classroom

In inquiry-based learning, teachers organize various science activities to include questions, experiments, demonstrations, and group discussions in ways that would enhance students' thinking and skills [41]. Biology teachers in inquiry-based lessons interacted with the student groups in multiple ways but the majority of interactions were teacher-led; teachers were more likely than students to initiate interactions [42]. In general, classroom interaction is affected by teacher's talk and the quality of talk may affect how teacher and students interact in classroom. Dialogic teacher talk is associated with higher interest levels; dialogic talk may trigger or support students' interest [43].

Questioning directs interactions in a classroom [44]. Through weekly practice and reflection, student teachers can develop their questioning practice within the context of face-to-face interaction with students [45]. Interaction through talking and questioning encourages students to respond and elicits students' thinking process [19]. Depending on the nature of the study activity, questioning sequences may be exploratory and facilitative rather than evaluative talk. In such discursive episodes, teachers' questions scaffold students' thinking and nudge students toward conceptual development instead of just assessing the correctness of their responses [19].

When studying classroom interaction, different question patterns and feedback-chains between teacher and students in the classroom have been found. The traditional question pattern in the classroom often starts with the teacher's initiation question followed by students' response and follow-up [46], initiation and response followed by evaluation [47], or a feedback chain of follow-up initiation, response, feedback and response, feedback-chain [48]. Mortimer and Scott [48] highlight the feedback from the teacher, which leads to a further response from a student; this form of interaction supports and may enable a dialogic interaction during lessons. Teachers may be able to change the nature of their discourse by changing the nature of the turn of an initiation-response-evaluation (IRE) questioning sequence from an evaluation to a reflective toss [49]. By asking questions that can help clarify meanings, examine a variety of views and monitor the discussion process, teachers and students can work together to refine their understandings towards more scientific conceptions [49].

1.2. Questioning in Inquiry-Based Lessons

Inquiry-based teaching has different forms from confirmation to open inquiries [50]. In the confirmation inquiry, students confirm a principle through an activity in which the results are known in advance; in structured inquiry students investigate a teacher-presented question through a prescribed procedure; in guided inquiry students investigate a teacher-presented question using student designed and selected procedures, and in open inquiry students investigate topic-related questions that are student formulated through student designed and selected procedures [50].

Even though the initiation of questioning may be a challenge for the teacher, it is significant what kind of question types that teachers use, especially in inquiry lessons. Teachers probably use the different questioning types in the same inquiry-based lessons. Goodman and Berntson [51] (p. 474) have divided questions into three general types: (1) "Why" questions are appropriate when the content of the question is familiar to students and when teachers can identify a given phenomenon and use a question to direct subsequent inquiry into the nature of the phenomenon; (2) "How" questions are more suitable in the context of the content that is not necessarily familiar to the students, asking a "how" question makes the phenomenon itself the object of study; (3) "Is" questions are useful for setting the stage for inquiry and possibly debating; this type of question can be used quite effectively for topics that do not have clear-cut answers.

Teachers' questioning can be based on the function of the question. According to Blosser [52] (p. 3), the major types of questions teachers ask are (1) managerial, to keep the classroom operations moving; (2) rhetorical, to emphasize a point, to reinforce an idea or statement; (3) closed, to check the retention of previously learned information and to

focus thinking on a particular point or commonly held set of ideas; (4) open, to promote discussion or student interaction, to stimulate student thinking and to allow freedom to hypothesize, speculate, and share ideas about possible activities.

Teachers use the different cognitive levels of questions in their inquiry lessons. In many science classrooms, lower-order questions are used extensively by teachers to evaluate the knowledge level of students; these questions elicit responses that require direct recalling from memory or explanations cited explicitly in the text [8] (p. 77). Correspondingly, higher-order questions aim at assessing higher cognitive skills such as analysis, synthesis, and evaluation [8] (p. 77). Based on the level of teacher questioning, it has been found that in mathematics classrooms, teachers' higher-order questions are associated with highly participatory answers from students and that teachers' lower-order questions are associated with simple answers from students [32]. Authoritatively oriented teacher questioning can limit students' science understanding, while dialogically oriented questions can enhance the breadth and depth of canonical and self-generated student knowledge [16]. Learning through biology-based research papers may be one way to provide a stimulus for question-asking and higher thinking levels by students [53]. In contrast to the average-progress and low-expectation teachers, the high-expectation teachers provided more time for students' learning and more feedback for students and used more open-inquiry questions in the classroom [54]. Further, Oliveira [22] found that student teachers' student-centered questions enabled longer and more articulated student responses, promoted a higher level of student thinking, enabled students toward tentative responses, and encouraged students toward authentic investigations.

The teacher's classroom experience may affect how he/she asks questions in a classroom. Benedict-Chambers, Kademian, Davis, and Palincsar [55] characterized the questioning practices of an experienced teacher. They observed that teachers used three questioning patterns: (1) focusing students on scientific practices, (2) supporting students in naming observed phenomena, and (3) guiding students in sense-making. Chin [18] studied how teachers used questions in classroom discourse to scaffold student thinking and encourage students to construct scientific knowledge, and found that teacher questioning was very purposeful when the questions were built around various forms of thinking to enable students to gradually ascend to higher levels of knowledge and understanding.

Open lesson plans, which are tentative and flexible, taking into consideration students' ideas, questions and interests, are valuable for teacher questioning [5]. Teachers ask questions to develop the lesson by not only generating the discussion but also guiding the discussion [5]. When a variety of hands-on activities were mediated through questions, hands-on practice served as anchor points for discussion [5]. In a study by Lee and Kinzie [56], in science small group practices, teachers asked more open-ended questions and teachers' questions were oriented toward prediction and reasoning. Furthermore, open and respectful pedagogical teacher's questioning elicited students' learning and decisions about next steps, and deep-level questions in the classroom improved vicarious student learning [57,58]. Teachers' use of specific and challenging focus questions in biology classrooms not only activated students' existing conceptions or ideas about the topic but also stimulated the active negotiation of meaning [59]. Problem-solving activities elicited more and a wider range of wonderment questions than teacher-directed activities [34].

Teachers' knowledge of teaching and questioning develop over time, based on practice and critical reflection on the inquiry practice. Development of pedagogical content knowledge (PCK) may occur in the important role between teacher's questioning and student's thinking process in inquiry [60]. Chan and Yung [60] studied experienced biology teachers when they taught the new topic to their students for the first time. They showed a three-part model about on-site PCK development: (1) stimulus; unanticipated student questions, unexpected student responses, environmental stimuli, for example, the teacher's realization of a student's misconception, (2) integration; subject matter knowledge, pedagogical knowledge, knowledge of students, for example, teacher retrieves the student's prior knowledge, and (3) response; invention of new instructional strategies, representa-

tions on the fly of the lesson, for example, teacher gives the examples to student to clarify the misconception.

In summary, teachers' questioning has been widely studied from various viewpoints. It is important that students have an opportunity for open-ended and hands-on practices in their inquiry lessons, which may advance teacher questioning in inquiry [5,50]. To study student teachers' questioning in inquiry-based lessons can elicit how teacher and students interact and how teacher can develop in questioning skills. Nevertheless, although the questioning has been in focus during lessons, few studies have considered inquiry-based lessons or biology lessons [24,59], which are the focus in this study.

1.3. Research Aim and Questions

For the development of science teacher education and promotion of inquiry-based teaching and learning, it remains important to identify student teachers' questioning in inquiry-based biology lessons. Identifying student teacher questioning in different stages of inquiry is valuable for understanding how to support student teachers to successfully implement inquiry-based teaching and questioning in biology education. It is important and valuable to study especially student teachers' questioning; student teachers are in the initiation stage of teaching work and may face challenges during inquiry lessons. The research questions that directed the study are:

RQ1: *To what extent do the student teachers ask questions in inquiry-based biology classrooms?*

RQ2: *What kind of questions do student teachers ask in primary and in secondary school in different stages of inquiry?*

RQ3: *How do student teachers differ in their questioning?*

2. Materials and Methods

This qualitative study is a multiple-case study including 12 different cases. In all cases, the focus was on what kind of questions student teachers ask during inquiry-based lessons. The context in the cases varies, ranging from primary school biology to upper secondary school biology with several biology topics.

2.1. Participants

In total, 12 voluntary student teachers participated in the study. Among them were five primary school (grades 1–6) student teachers (one male and four female student teachers), six lower secondary school (grades 7–9) student teachers (one male and five female student teachers), and one upper secondary school female student teacher. Primary school student teachers were named Mary, Harry, Linda, Susan, and Kathy; lower secondary school student teachers were named Jessica, Joan, Catherine, Sirena, Tina, and Patrik; the upper secondary school student teacher was named Evelyn. Both primary school and secondary school student teachers were selected for this study to achieve a wider viewpoint for student teacher questioning in inquiry-based biology lessons; teachers and students practice inquiry through primary school and secondary school according to the Finnish curriculum. All student teachers studied in one teacher education institute in Finland.

Participants were performing training periods for their teachers' pedagogical studies. Teachers' pedagogical studies are obligatory in Finnish teacher education. Duration of the training period was between two and three months in total in primary school and secondary school. Student teachers plan and implement their own instruction lessons; training periods were implemented at the University Training School. Both primary school student teachers and secondary school student teachers practiced inquiry-based teaching and questioning during their training period. Four student teachers (Mary, Harry, Susan, Kathy) were performing their third out of four teacher training periods and one student teacher (Linda) was performing her second teacher training period at the primary school

level. At the secondary school level, all student teachers performed their second out of the four teacher training periods.

Secondary school student teachers had studied advanced studies in biology (60 ECTS) and primary school student teachers had studied science studies including biology (total 13 ECTS). Student teachers were familiarized with inquiry teaching during their studies.

2.2. Data Collection

Fourteen student teachers' lessons in primary school, six lessons in lower secondary school, and one lesson in upper secondary school were video and audio recorded, totaling 21 lessons. In primary school, each student teacher implemented one to six lessons; in secondary school, student teachers had one or two lessons. The duration of one video recorded lesson was approximately 45 min. Written consent from the student teachers to collect and use the data for research and educational purposes was obtained, and the student teachers could withdraw from the research at any time. One video camera was directed toward the student teacher, and the video recording did not disturb the lesson. Student teachers had a wireless microphone, which captured the voices of the student teacher and students. Video recording has been found to be an appropriate data collection method in examining teachers' actions [61,62], including teacher questioning [9].

2.3. Description of the Lessons

Student teachers planned the lessons with the scaffold of the supervising teacher in the training school, but the final version of the lesson plan was the student teachers' own responsibility. The training lessons of student teachers were based on a curriculum that emphasizes inquiries. Student teachers' biology lessons were designed to follow the idea of inquiry-based learning. Pedaste et al. [63] have developed a framework that describes an inquiry cycle. According to this framework, inquiry-based learning begins with Orientation and flows through Conceptualization to Investigation; inquiry-based learning usually ends with the Conclusion and Discussion stages. In this study, student teachers' inquiry-based lessons included three stages: the introduction stage (IS, including orientation and conceptualization), the examination stage (ES, investigation) and the conclusion stage (CS, including conclusion and discussion). During one lesson, a part of all the three inquiry stages appeared. In primary school cases, the contents of the lessons were related to organic materials; perch (*Perca fluviatilis*), grub of meal beetle (*Tenebrio molitor*), pink (*Dianthus*), water flea (*Cladocera*), and gastropod (*Gastropoda*). Students participated in laboratory work, made observations of invertebrates, performed simple science trials, read science literature, and did writing exercises in primary school (Table 1). Secondary school lessons included laboratory work, workstation work, written exercises, posters, and presentations; students often worked in small groups especially in secondary school (Table 1). Primary student teachers and secondary student teachers used organic materials such as species, examination of species, and animal cells in their inquiry-based lessons, which provided opportunities for students to understand biological sustainability.

Table 1. Topics of recorded lessons (IS = introduction stage; ES = examination stage; CS = conclusion stage).

Student Teacher (Grade)/Inquiry Stage (Time)	Topic of Lesson/Inquiry
Mary's lessons 1–3 (grade 1) IS (17 min); ES (96 min); CS (7 min)	Breeding of meal beetle grub (<i>Tenebrio molitor</i>)/examination of own meal beetle grub Concepts and meal beetle grub/examination of own meal beetle grub Meal beetle grub/examination of own meal beetle grub
Harry's lessons 1–6 (grade 2) IS (34 min); ES (121 min); CS (26 min); furthermore IS and ES stages occurred simultaneously (52 min) and CS and ES stages occurred simultaneously (9 min)	Classification of animals, plants, and mushrooms/classification of species Preconceptions/determination of students' preconceptions Hen's egg/examination of hen's eggs Development stages of chicken/examination of hen's egg and identifying of development stages of chicken Plants in different habitats/comparison of plant habitats and examination of what will happen in pink (<i>Dianthus</i> spp.) trial Observation of pink trial/examination of what will happen in pink trial

Table 1. Cont.

Student Teacher (Grade)/Inquiry Stage (Time)	Topic of Lesson/Inquiry
Linda's lessons 1–2 (grade 2) IS (19 min); ES (35 min); CS (34 min)	Recycling/examination of collection boxes in classroom Compost/examination of the different layers of compost
Susan's lessons 1–2 (grade 2) IS (5 min); ES (55 min); CS (16 min)	Water flea (<i>Cladocera</i>)/examination of constituent parts of water flea and observation of movement of water flea Water flea/examination of water flea and gastropod in the same petri dish
Kathy's lesson 1 (grade 3) IS (5 min); ES (26 min); CS (3 min)	Fish anatomy/examination of constituent parts of a fish
Jessica's lessons 1–2 (grade 7) IS (10 min); ES (58 min); CS (14 min)	Crayfish (<i>Astacus astacus</i>)/examination of ecology and anatomy of crayfish Crayfish/examination of ecology and anatomy of crayfish
Joan's lesson 1 (grade 7) IS (9 min); ES (29 min); CS (6 min)	Fish anatomy/examination of constituent parts of a fish
Catherine's and Sirena's lesson 1 (grade 9) IS (8 min); ES (31 min); CS (2 min)	Human heredity/familiarization into DNA structure by poster Human heredity/examination of probability of gender
Tina's lesson 1 (grade 9) IS (19 min); ES (20 min); CS (5 min)	Animal cell/examination of constituent parts of an animal cell by microscopy
Patric's lesson 1 (grade 9) IS (2 min); ES (20 min); CS (18 min)	Blood cells/examination of blood cells by science literature
Evelyn's lesson 1 (upper secondary school) IS (0 min); ES (18 min); CS (28 min)	Environmental risks/preparing and showing of poster

2.4. Data Analysis

Data analysis was theory-driven content analysis [64–66]. In the first stage of analysis, video recordings were watched several times to get an overview of the student teachers' questions. In the second stage, all student teachers' interrogative sentences were transcribed and used as the units of analysis. This was studied prior research and different question categories [5,51,52,55] and noticed that the question categories of Kawalkar and Vijapurkar [5] were quite appropriate for this study data. The characterization of interrogative sentences was modified from the categories of Kawalkar and Vijapurkar [5]. It was found, however, that some additional categories were needed to describe student teachers' questioning better in different inquiry stages of biology lessons. Inquiry lessons of student teachers included, for example, biological concepts, species, and examination. The question categories such as evaluation, hypothesis, concept/basic knowledge of species, and factual knowledge were added to the initial categorization. The student teachers' questions were categorized into the following categories: (1) probing further (initial student responses); (2) guiding the entire class towards the scientific concepts; (3) refining conceptions and explanations; (4) generating ideas and explanations; (5) evaluation; (6) hypothesis; (7) exploring pre-requisites/setting the stage; (8) concept/basic knowledge of species; (9) factual knowledge; and (10) classroom management. In many science classrooms, teachers use lower-order questions extensively to evaluate the knowledge level of students; these questions elicit responses that require direct recalling from memory. Higher-order questions elicit students' higher cognitive skills such as analysis, synthesis, and evaluation [8]. In this study, question categories such as probing further, guiding the entire class towards the scientific concepts, refining conceptions and explanations, generating ideas and explanations, evaluation and hypothesis are indicated more as *higher-order questioning*; question categories such as exploring pre-requisites, concept/basic knowledge of species, factual knowledge, and classroom management are seen more as *lower-order questioning* [8]. Question categories with descriptions and examples are shown in Table 2. Additionally, it was noticed during analysis that student teachers were found to belong

to different questioner groups as the number of questions and quality of questions. After this, student teachers were grouped into four questioner types according to the number of questions and quality of questions they asked. The types are: 20–35 questions per lesson/85–98% lower-order question categories; 20–35 questions per lesson/58–76% lower-order and 12–42% higher-order question categories; 50–84 questions per lesson/85–98% lower-order question categories; 50–84 questions per lesson/58–76% lower-order and 12–42% higher-order question categories. Mary and Harry in primary school and Joan and Jessica in secondary school represented four different questioner types. The questioning of these four student teachers is presented in the results section.

Table 2. The question categories with descriptions (modified from Kawalkar and Vijapurkar [5]).

Question Categories	Description/Question Examples
Probing further (initial student responses)	Asking for reasoning, clarification, elaboration, or justification of student comment; pointing out contradictions; the emphasis of this category is on students' initial ideas; for example "Crayfish eats its own skin, but why?"
Guiding the entire class towards the scientific concepts	Encouraging wider students' response; urging to consider a variety of viewpoints; encouraging students to take up a critical attitude; for example, "Did we discuss with you that it has a carapace and a tail separately so how do they affect it?"
Refining conceptions and explanations	Asking for a way to test or find out different issues or views such as in science trial; asking for inference; invoking reflective thinking; usually teacher's initial idea; for example, "How do you draw the conclusion that it would be the lungs or heart?"
Generating ideas and explanations	Asking for explanations; drawing on what has been observed or calling for further observation; asking for an opinion or stance; for example, "How can we observe that a plant is growing?"
Evaluation	Asking evaluation or comparison of different issues such as pictures, species or environments; for example, "Did you find what differences there are between a male and a female?"
Hypothesis	Asking to make the hypothesis or forecast what will happen in inquiry task; for example, "What will happen when the algae is added to the vessel?"
Exploring pre-requisites/setting the stage	Asking for students' preconceptions; eliciting students' prior experience; inviting students to integrate the issues with prior knowledge; for example, "Have you encountered these water fleas before?"
Concept/basic knowledge of species	Inviting the definition of concepts or basic knowledge of species such as structure learning; for example, "What is the substance inside a cell?"
Factual knowledge	Asking for mainly basic information; inviting students to repeat factual knowledge or asking student's opinion without reasoning; for example, "Can you tell me what the picture represents?"
Classroom management	Inviting if students have, for example, something to ask or problems with the task.

While the question analysis was conducted by the main analyzer, for reliability and validity of the analysis, the main analyzer and the second analyzer analyzed the questions separately [5]. The second analyzer analyzed questions of three student teachers (14% of the total). For the categories coded, inter-observed agreement was 63%. After this, the main analyzer and the second analyzer discussed the question categories. During the discussion, disagreements were resolved between the analyzers to achieve an acceptable 100% inter-observer agreement, and the question categories were fixed.

3. Results

3.1. To What Extent Do the Student Teachers Ask Questions in Inquiry-Based Biology Classrooms?

In general, student teachers asked many questions in their biology lessons. No difference between student teacher questioning related to student teachers' training period stage or the number of video-recorded lessons were found. At the primary school level, student teachers asked a total of 513 questions during their lessons (on average 36.6 questions per lesson). Similarly, student teachers in secondary school asked a total of 321 questions during their lessons (on average 45.9 questions per lesson). Student teachers asked more questions in the conclusion stages (1.3 questions per minute) and in the introduction stages (1.2 questions per minute) in primary school, while secondary school student teachers asked more questions in the examination stages (1.2 questions per minute) and in the conclusion stages (1.0 questions per minute). Pearson's chi-square test was carried out against the levels of school and asked questions within different lesson stages. The tests showed that there was a significant difference (Pearson $\chi^2 = 46.940$; $df = 2$; $p < 0.001$) in the asked questions during different inquiry stages between in primary school and secondary school. Primary student teachers asked significantly more questions during introduction stage (Adjusted Residual = 6,7) whereas secondary student teachers asked significantly more questions during examination stage (Adjusted Residual = 5,3) [67] (Table 3).

Table 3. Distribution of questions in primary school and secondary school.

	Introduction Stage Number of Questions (%) /Number of Questions Per Minute	Examination Stage Number of Questions (%) /Number of Questions Per Minute	Conclusion Stage Number of Questions (%) /Number of Questions Per Minute	Total
Primary school	154 (30%)/1.2	246 (48%)/0.7	113 (22%)/1.3	513
Secondary school	33 (10%)/0.7	214 (67%)/1.2	74 (23%)/1.0	321
Total	187	460	187	834

3.2. What Kind of Questions Do Student Teachers Ask in Primary and in Secondary School in Different Stages of Inquiry?

The number of student teachers' questions in different inquiry stages according to the question categories (Table 2) in primary and secondary school are shown in Figure 1.

In primary school and in secondary school, student teachers' questions were found to belong to all question categories (Figure 1). During the introduction stage, primary and secondary student teachers mainly asked factual knowledge and the definitions of concepts or basic knowledge of species. They also asked, to some extent, students to generate ideas and explanations, refine conceptions and explanations, and explore pre-requisites. Moreover, during the examination stage, primary and secondary student teachers mainly asked questions requesting factual knowledge and the definitions of concepts and basic knowledge of species. They also asked students to generate ideas and give explanations as well as to present hypotheses. During the conclusion stage, primary and secondary student teachers again mainly asked questions requesting factual knowledge and the definitions of concepts and basic knowledge of species. To some extent, primary and secondary student teachers also asked students to refine conceptions and explain, while other question categories appeared only occasionally. Pearson's chi-square test was carried out for both levels of school in order to investigate the levels of questions; lower-order against higher-order. Concerning the primary school, the test showed no statistically significant difference (Pearson $\chi^2 = 2.010$; $df = 2$; $p > 0.05$) between the lower-order and higher-order questions during different inquiry stages. Interestingly, there was a significant difference (Pearson $\chi^2 = 15.274$; $df = 2$; $p < 0.001$) in secondary school between the asked lower-order and higher-order questions against the different inquiry stages. Secondary student teachers asked significantly more lower-order questions during introduction stage

(Adjusted Residual = 2,5) and significantly more higher-order questions during conclusion stage (Adjusted Residual = 3,4) [67] (Figure 1).

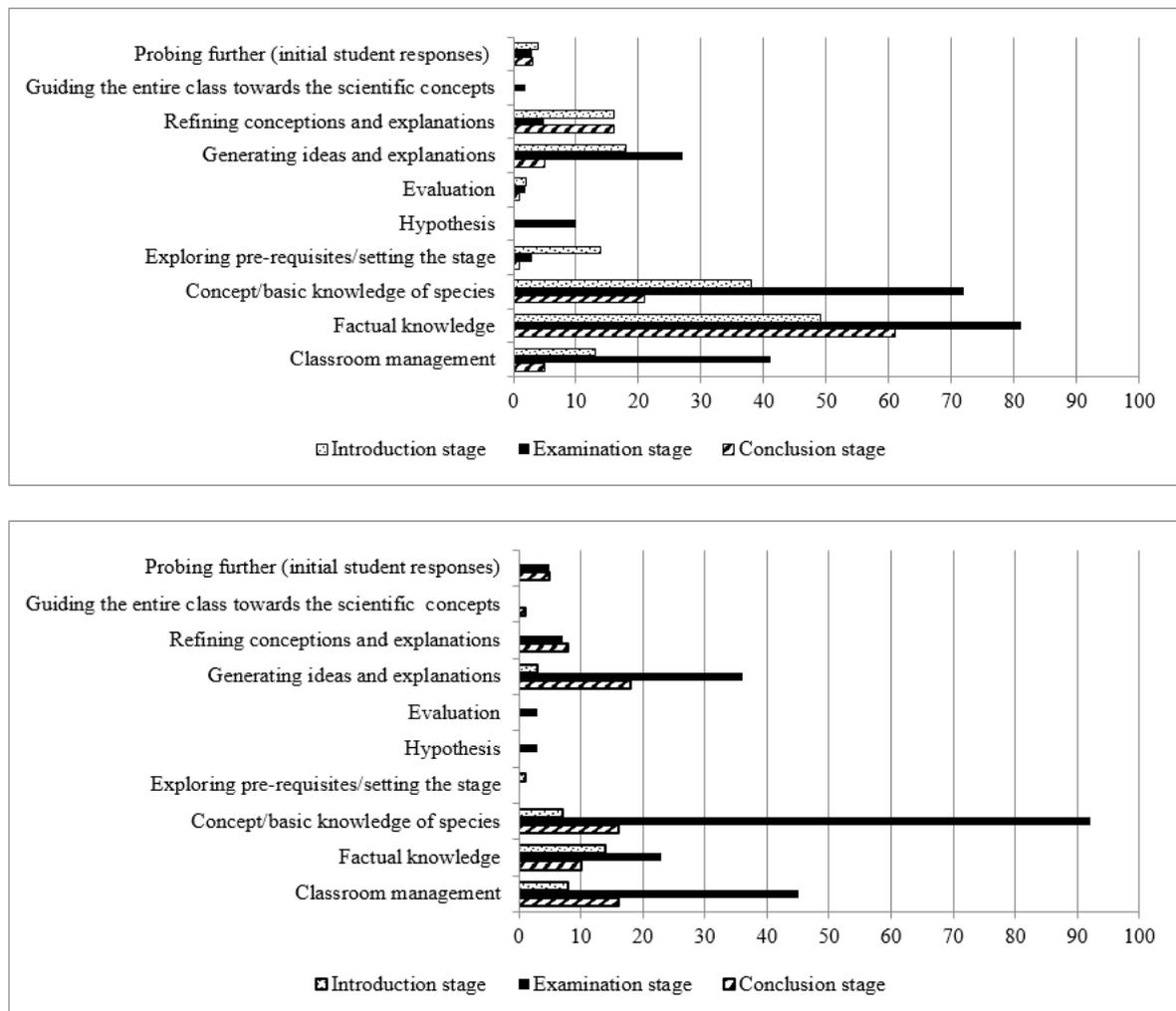


Figure 1. The number of questions in each question category during different inquiry stages: primary (**upper**) and secondary (**lower**) school student teachers. The horizontal axis shows the number of questions, and the vertical axis the categories of questions.

3.3. How Do Student Teachers Differ in Their Questioning?

Student teachers were grouped into four questioner types based on the number of questions and quality of questions. Six student teachers (two in primary school and four in secondary school, Table 4) asked a few questions that were lower-order questions. These student teachers are named “Questioners of facts”. Three student teachers (two in primary school and one in secondary school, Table 4) also asked few questions, which were both lower-order and higher-order questions; these student teachers are called “Questioners of arguments”. One student teacher (in secondary school, Table 4) asked more questions than these groups; however, her questions were lower-order questions. She is called a “Questioner of concepts”. Two of the student teachers (one in primary school and one in secondary school, Table 4) also asked many questions, both lower-order and higher-order questions; they are called “Questioners of knowledge”.

Table 4. The questioner types of student teachers.

Questioner Types	Primary School	Secondary School
Questioners of facts: 20–35 questions per lesson/85–98% lower-order question types	Mary, Kathy	Catherine/ Sirena, Tina, Evelyn
Questioners of arguments: 20–35 questions per lesson/58–76% lower-order and 12–42% higher-order question types	Harry, Susan	Patric
Questioners of concepts: 50–84 questions per lesson/85–98% lower-order question types		Joan
Questioners of knowledge: 50–84 questions per lesson/58–76% lower-order and 12–42% higher-order question types	Linda	Jessica

The cases of Mary, Harry, Joan, and Jessica represent each different questioner type (Table 4). Primary school student teacher Mary was a typical questioner asking factual knowledge, primary school student teacher Harry was a typical questioner who demanded arguments from students, secondary school student teacher Joan asked questions related to concepts and species knowledge, and secondary school student teacher Jessica asked for basic knowledge but also asked for explanations. Compared to other student teachers, Mary used mostly lower-order questions, particularly asking factual knowledge. She asked many questions related to classroom management. Harry asked more higher-order questions than others. He asked questions for generating ideas and explanations and asked students to refine conceptions and explanations, as well as guided the whole class with his questions. Joan asked many questions about concepts and factual knowledge of species, mainly lower-order questions. Jessica at the secondary school level was quite similar to Harry in her questioning, but Jessica asked more questions (Table 5).

Table 5. Distribution of question categories of student teachers in the cases of Mary, Harry, Joan, and Jessica. The colored area shows the different distribution of the question categories.

Categories of Question	Number of Question Categories of All Lessons in Different Inquiry Stages												Total
	Primary School			Secondary School									
	Mary			Harry			Joan			Jessica			
	IS	ES	CS	IS	ES	CS	IS	ES	CS	IS	ES	CS	
Probing further (initial student responses)	0	0	0	4	3	1	0	0	0	0	4	3	15
Guiding the entire class towards the scientific concepts	0	1	0	18	16	2	0	0	0	0	32	12	3
Refining conceptions and explanations	1	1	0	15	4	3	0	0	1	0	7	3	35
Generating ideas and explanations	0	0	0	0	2	0	0	0	0	0	0	1	81
Evaluation	5	1	0	0	0	0	0	0	0	1	0	0	4
Hypothesis	0	0	0	0	0	1	0	0	0	0	3	0	8
Exploring pre-requisites/setting the stage	0	0	0	0	6	0	0	0	0	0	2	0	7
Concept/basic knowledge of species	3	9	1	31	20	8	0	30	0	0	46	9	157
Factual knowledge	1	25	2	10	36	8	0	8	0	2	6	5	103
Classroom management	0	25	0	7	7	0	2	5	4	5	20	8	83
Total	10	62	3	85	94	23	2	43	5	8	120	41	496

The following four excerpts contextualize student teacher questions in different inquiry stages. During the introduction stage, Mary asked at first a couple of questions, and next, the students read the meal beetle text. In the examination stages, the students examined the meal beetle grub, and during the conclusion stage, the students checked

the observation sheet of the meal beetle grub. In all inquiry stages, Mary asked mainly pre-requisites, questions to which the students responded naming concepts, questions about basic knowledge of meal beetle grub and questions factual knowledge such as that related to metamorphosis and number of legs of grub, that is, mainly lower-order questions (Table 6).

Table 6. Excerpts of discussions between Mary and students.

Mary's lesson 1. During the Introduction Stage (IS) of the First Lesson, Mary and Students Discuss Invertebrates such as Insects, and Mary Asks Students' Preconceptions.	Mary's Lesson 2. During the Introduction Stage (IS) of Lesson 2, Mary and Students Discuss for Concepts and Scientific Terms of Meal Beetle Grub.
Lesson 1	Lesson 2
Mary: What insects do you know? (exploring pre-requisites/setting the stage)	Mary: What it means when it is said that it creates its own skin? (concept/basic knowledge of species)
Mary: Student 1.	Mary: Why does it creates its skin again? (refining conceptions and explanations)
Student 1: So, at least a ladybird, ant ...	Mary: Student 7.
Mary: Student 2.	Student 7: Because it skin stays too small for larvae.
Student 2: A grasshopper.	Mary: Yes.
[Students enumerate a species.]	Mary's lesson 3. During the examination stage (ES) of lesson 3, Mary and students examine more exactly a meal beetle grub.
Mary: Have seen any species that have been mentioned? (exploring pre-requisites/setting the stage)	Lesson 3
Students: Yeah [unanimously].	Mary: Look at the left eye, do you see it? (factual knowledge)
Mary: Where have you seen them? (exploring pre-requisites/setting the stage)	Student 1: Yeah.
Mary: Student 3.	Mary: Do you see ... what do you see? (factual knowledge)
Student 3: I think ... I found a beetle under snow ...	Mary: Do you see yellow? (concept/basic knowledge of species)
Mary: How many of you have seen an ants' nest? (exploring pre-requisites/setting the stage)	Student 1: I can see.
Mary: Yeah [many of students put up their hands.]	Mary: Do you see legs? (concept/basic knowledge of species)
Students tell their experiences ...	Student 1: Yes.
Mary: Have looked closely at what ants build there? (exploring pre-requisites/setting the stage)	Mary: Okay, then student 2's turn.
Mary: Student 4.	
Student 4: At first I did not observe ants ...	

During the introduction stage (lesson 5), Harry and his students made observations about plant pictures, and the students compared the pair of pictures. During the examination stage, the students observed the initial stage of the plant trial; three plants were set in three different color-sample pots of water, and the students made hypotheses about what will happen in different plant samples. In the next lesson, Harry and the students continued observing the plants. The students also watched a video concerning the spreading of water through the plant and discussed the topic. During the conclusion stage, the students discussed their plant trial and filled in an observation sheet about the plant. During the introduction stage (lesson 5), Harry asked for explanations as the students made observations for nature pictures. Harry also asked extra questions in relation to students' prior questions. During the examination stage, in both lessons (lessons 5 and 6), Harry asked questions concerning the plant trial. Harry asked students to present hypotheses or explanations about the plant trial. During the conclusion stage (lesson 6), Harry asked students to explain how water evaporates in plants. Harry facilitated an interactive talk with the students and occasionally developed student understanding by questioning (Table 7).

Table 7. Excerpts of discussions between Harry and students.

Harry's lesson 5. During the Introduction Stage (IS) of Lesson 5, Harry Asks What Differences Students Observe between Picture A (Plants in Dry Climate) and Picture B (Plants in a Humid Climate).	Harry's Lesson 6. During the Examination Stage (ES) of Lesson 6, Harry and Students Examine the Rotation of Water in the Plant. Harry Asks a Several Questions for Students.
Lesson 5	Lesson 6
Harry: What things you can observe on the screen, anyway? (factual knowledge)	Harry: What has happened to the water? (factual knowledge)
Harry: Student 1.	Harry: Student 4.
Student 1: There is a palm and a lot of sand . . .	Student 4: It has evaporated or a flower has absorbed water.
[Students discuss . . .]	Harry: Tell me, what has happened if it has evaporated? (guiding the entire class towards the scientific concepts)
Student 2: There are many more animals than in the other [picture].	Student 4: It has evaporated because . . . or it . . . water has risen toward the plastic dish.
Harry: Ahaa. In which of pictures are there more animals? (factual knowledge)	Harry: Ahaa, okay.
Student 3: In the lower picture.	Harry: Student 5.
Harry: How did you conclude this? (refining conceptions and explanations)	Student 5: If there is food coloring, I observed that there is food coloring in the lower edge of the flower.
[Harry and students discuss]	Harry: Who else had a similar observation as student 5? (generating ideas and explanations)
Harry: I want to seize on a good idea of student 2. Student 2 said that there are fewer plants in the upper picture than in the lower picture.	Harry: Yeah, student 6.
Harry: How is that? [the amount of species is different in the pictures] (probing further (initial student responses))	Harry: We can think more deeply about this observation, this is a very interesting observation.
Harry: Student 4.	Harry: Has a similar phenomenon happened here, in the red water? (factual knowledge)
Student 4: There is not much water in the desert.	Students: [Students think and make observations.]
Harry: There is not.	Harry: Here, has the flower changed in color? (factual knowledge)
Harry: Why there is not much water? (probing further (initial student responses))	Harry: How is this possible? (generating ideas and explanations)
[Harry and students discuss]	Harry: Student 7.
Harry: Why there are more plants in the lower picture? (probing further (initial student responses))	Student 7: Perhaps . . . because it uses that energy . . . as it absorbs the same color water so it is seen a similar color.
Harry: Student 5.	Harry: How can a color spread there? (generating ideas and explanations)
Student 5: There is more water.	Student 7: It moves through the stem.
[Harry and students discuss]	Harry: Where it would be carried from stem? (generating ideas and explanations)
Harry: What things do plants needs to grow? (refining conceptions and explanations)	Harry: Student 8.
	Student 8: I think . . . they are so thin that a color . . . when it spreads through stem up . . . that a color . . . something of that substance . . . it spreads toward the flowers.

During the short introduction stage, Joan guided students to small group studies by asking questions mainly related to classroom management; the teaching approach was working at a workstation. During the examination stage, the students preserved a fish and examined its anatomy. Joan mainly asked concept-related questions and basic knowledge of the fish, such as finding its tongue and teeth. She also asked for factual knowledge and questions related to classroom management. During the short conclusion stage, at the end of the lesson, the students filled in the examination sheet about the fish, and Joan asked mainly classroom management questions. Joan often asked for concepts and basic knowledge of fish. The questions were lower-order questions, especially during the examination stage (Table 8).

Table 8. Excerpts of discussion between Joan and students.

Joan's Lesson 1. During the Examination Stage (ES) of Lesson 1, Joan and Students Examine Constituent Parts of a Fish.	
Lesson 1	
Joan:	What do you find there? (concept/basic knowledge of species)
Joan:	What do you find? (concept/basic knowledge of species)
	Student 1: Tongue
Joan:	Is there a tongue? (concept/basic knowledge of species)
Joan:	What do fish have in their mouths? (concept/basic knowledge of species)
	Student 2: Teeth
Joan:	But if you think about the senses.
	Student 2: Taste
Joan:	Sense of taste, yeah.
	Student 2: Tongue
Joan:	Can you see a tongue there? (concept/basic knowledge of species)
	Student 2: Yeah, I can see.
	Joan: Yeah, very good.
Joan:	Where is the smell organ? (concept/basic knowledge of species)
	Student 3: Here
Joan:	It is not there.
	Student 3: Here
Joan:	There is a smell organ.
Student 3:	Can you cut it . . . ?

During the short introduction stage, Jessica showed the students what they were going to study in small groups in the next lessons in workstations. She mainly asked classroom management questions, questions requesting factual knowledge answers and pre-requisites of students. During the examination stage, students then filled in, in small groups, the examination sheet when searching for knowledge of crayfish. During the conclusion stage, at the end of the second lesson, students' observation sheet of crayfish was checked. Jessica and students discussed the ecology and anatomy of crayfish. During the examination and the conclusion stages, Jessica mainly asked for concepts and basic knowledge of crayfish; she tried to generate ideas and explanations and asked further classroom management questions. Jessica also asked students to refine conceptions and explanations about the anatomy and actions of crayfish, aiming to enhance understanding of ecological sustainability. Although Jessica often asked about concepts and basic knowledge of crayfish, such as questions about senses and the hard skin of crayfish, i.e., lower-order questions, she also indicated her interest toward higher-order questions to some extent, especially during the examination and the conclusion stages (Table 9).

Interestingly, even though student teachers asked many questions in their inquiry-based biology lessons in primary and secondary school, question categories were mainly similar between primary and secondary school. Factual knowledge was often asked; student teachers used higher-order questioning such as analyzing, synthesizing, and evaluating only occasionally, both in primary and secondary school levels.

Table 9. Excerpts of discussion between Jessica and students.

Jessica's Lesson 1. During the Examination Stage (ES) of Lesson 1, Jessica and Students Discussed the Senses of Crayfish.	Jessica's Lesson 2. During the Examination Stage (ES) of Lesson 2, JESSICA and Students Discuss for Crayfish's Skin.
Lesson 1	Lesson 2
Jessica: How are you getting on with your work? (classroom management)	Jessica: As a crayfish gets too big for own skin . . . it becomes tight . . . what does a crayfish do to its own skin? (refining conceptions and explanations)
Student 1: Here is not . . .	Student 3: A crayfish changes its own skin.
Jessica: Where does a crayfish need its senses for? (concept/basic knowledge of species)	Jessica: Yeah. A crayfish changes it. And it is not thrown away.
Jessica: What senses you can find there? (concept/basic knowledge of species)	Jessica: A crayfish eats its own skin, so why? (probing further (initial student responses))
Student 2: It uses the senses to sense.	Student 4: . . .
Jessica: Yeah.	Jessica: Yeah. It loosens its old skin and munches on it.
Jessica: What senses you can find here? (concept/basic knowledge of species)	Jessica: But why, what is the skin composed of? (generating ideas and explanations)
Student 3: Are there eyes . . . ?	Jessica's lesson 2. During the conclusion stage (CS) of lesson 2, Jessica and students check the observation sheet of crayfish.
Jessica: Yeah, eyes. The sense of sight, yeah.	There is interactive discourse between Jessica and students, and Jessica asks students many questions.
Jessica: Where does a crayfish need the sense of sight? (generating ideas and explanations)	Lesson 2
Student 2: To see . . .	Jessica: Okay. Have you found an answer . . . ? (classroom management)
Jessica: Yeah.	Student 5: . . .
Jessica: What does a crayfish need to observe in a lake? (generating ideas and explanations)	Jessica: Why does the female crayfish have a broader tail? (probing further (initial student responses))
Student 2: As it eats . . .	Student 5: For it to keep . . . its eggs.
Jessica: Yeah. what else? (generating ideas and explanations)	Jessica: That is right. The eggs of a crayfish are preserved under its tail for protection.
Student 2: It must be careful so that a predator does not attack.	Jessica: Do other groups have something to add? (generating ideas and explanations)
Jessica: Yeah.	Jessica's lesson 2. During the conclusion stage (CS) of lesson 2, Jessica and students discuss the quality of water in crayfish's environment.
Jessica's lesson 2. During the examination stage (ES) of lesson 2, Jessica and students discuss the hard skin of a crayfish.	Lesson 2
Lesson 2	Jessica: Yeah . . . Yes. In other words, the environment is important it must have food and cover. Was there something about the quality of water that you found? (generating ideas and explanations)
Jessica: In other words, what must a crayfish have if it has not backbone? (concept/basic knowledge of species)	Student 6: In the oxygenic quality [the quality of water].
Student 1: A hard skin.	Jessica: Yeah, in the oxygenic quality.
Jessica: Yeah, a hard skin. Very good.	Jessica: Why must crayfish have oxygenic water? (probing further (initial student responses))
[Discussion between Jessica and students . . .]	Jessica: Where is the oxygen in its water? (probing further (initial student responses))
Jessica: The skin is connected with appearance of a crayfish.	Jessica: How does a crayfish get the oxygen from water? (refining conceptions and explanations)
Student 2: In other words, it has a hard skin.	
Jessica: Yeah, a hard skin.	
Jessica: But what is matter with skin . . . if man grows, also backbone grows.	
Jessica: But what is the problem with crayfish? (generating ideas and explanations)	
Student 3: [Student explains . . .]	
Jessica: Yeah, the skin is changed at a certain stage	
[Discussion between Jessica and students . . .]	
Jessica: Another student group could guess that the crayfish eats its own old skin.	
Jessica: But why does the crayfish need to eat its old skin? (probing further (initial student responses))	

4. Discussion

In both the primary and secondary school contexts, student teachers' questioning was examined in different stages of inquiry-based biology lessons: the introduction, examination, and conclusion stages. The results revealed that direct student teacher questioning dominated in inquiry-based biology lessons, supporting previous research [3,4]. Student teachers requested factual knowledge or often invited the definition of concepts supporting the findings of Biggers [1] and Eshach et al. [2]. Overall, the student teachers asked questions in which the correct response is known beforehand, as found in several previous

research projects [5–8]; for example, the student teachers asked for facts about the anatomy of species during all inquiry stages, both in primary and secondary school. The student teachers' questions about factual knowledge, such as identifying, recalling, and interpreting, probably rarely lead toward a deeper understanding of biology lessons. In comparison, higher-order questioning from student teachers, such as analyzing, synthesizing, and evaluating questions, may promote deeper understanding and scaffold students' learning [57,58]. However, in this study, the student teachers asked analyzing, synthesizing, and evaluating questions only occasionally, as found in prior studies c.f. [2,12,13], mainly in examination and conclusion stages, both in primary and secondary school levels. The student teachers' questions rarely encouraged students' biological understanding and probably only weakly scaffolded students to analyze or probe their own ideas and views, such as those about biological sustainability, during inquiry-based biology lessons c.f. [68]. Similarly, Pham and Hamid [12], as well as Tavakoli and Davoudi [13], found that teachers mainly asked questions as to check students' memory.

4.1. Primary School Context

In primary school, the student teacher and students examined, for example, a meal beetle grub, which was a genuinely new and interesting topic for students and generated interactive discussion between student teacher and students in biology lessons. Primary student teachers asked significantly more questions during the introduction stage when student teachers introduced students for inquiry theme. Primary student teachers only occasionally used higher-order questions, such as those asking for reasoning, clarification, or justification, during their lesson, as suggested in previous research [12,13]. Additionally, in primary school, the student teachers often tried to encourage their students to elicit their own ideas and opinions, which can generate more discussion in science lessons, as well as higher-order questions, such as those about the synthesis and analysis of biology knowledge, as also Chin [19] states. On the other hand, the student teachers' questions about conceptual or factual knowledge of species are also probably valuable and significant during biology inquiries; inquiry-based learning may deepen the student teachers' questioning of knowledge about species.

4.2. Secondary School Context

In secondary school, student teachers also asked many questions as students examined, for example, the animal cell or the constituent parts of a fish in laboratory work c.f. [24]. Secondary student teachers asked significantly more questions during examination stage when student teacher and students performed inquiry trials. Student teachers in secondary school, like student teachers in primary school, mainly asked about concepts, facts and, for example, the anatomy of fish during laboratory working, especially during the examination stage. They asked significantly more fact questions during the introduction stage and, correspondingly, higher-order questions, such as those asking for reasoning, clarification, or justification, were asked significantly more during the conclusion stage. It is noteworthy that findings showed little difference in student teacher questioning between primary and secondary school, even though they have studied biology at different levels. The student teachers' study of biology is probably not only adequate for the development of questioning skills, but the development and skill of student teachers' questioning demands active practice and training in the classroom for an extended period.

4.3. Development of Questioning

Student teachers often encouraged students to interact with each other, which may also advance deep student teacher questioning in science lessons, as Lin et al. [26] found that teachers' skills in using higher-level questions can be promoted through the treatment of collaborative reflection in inquiry lessons. Similarly, Weiland et al. [45] have emphasized that student teachers can develop their questioning practices by interacting with students. However, even though student teachers genuinely generated discussion with students,

higher-order questioning between student teachers and students was low in inquiry lessons. The student teachers' lower-order questioning, presumably, weakly scaffolded inquiry discussion between student teachers and students, student teachers' lower-order questioning generated only simple and short answers of students as Ni et al. [32] stated.

The student teachers tried to evoke discussion in small student groups, which may advance student teacher questioning in inquiry-based biology lessons like Weiland et al. [45] showed in their study. In the inquiry-based lessons, the students often enthusiastically engaged in discussion in small groups but mainly with each other; therefore, students' small-group activities weakly elicited the student teacher's questioning, especially higher-order questioning, even though the student teachers used some hypothesis and prediction questioning, especially in the examination stage of lessons, which may lead toward higher-order questioning. In comparison, Lee and Kinzie [56] found that teachers asked more open-ended questions during science experiments, which typically happened in a small group setting. In these experiments, teachers appeared to use open-ended questions to encourage students to predict and reason [56].

The student teachers' challenges in classroom questioning may be case because, as Roth [17] has pointed out, questioning is a complex practice in the classroom, and student teachers may have had challenges in their training regarding inquiry-based biology instruction with respect to asking higher-order questions. Inquiry-based biology lessons may inherently generate more questions, especially questions based on analysis, synthesis, and evaluation. Teachers' practice questioning, especially during inquiry-based lessons, may develop teachers' as well as student teachers' questioning skills; likewise, Cetinkaya and Özyürek [69] observed that inquiry-based activities increased student teachers' science-teaching skills. "Why" and "How" questions may be challenging for student teachers, hence, the scaffolding of questioning of student teachers may be weak in inquiries. However, "Why" questions, "How" questions, and "Is" questions are valuable and significant for inquiry lessons [51], and teachers' use of different question categories may contribute to and deepen the understanding of biology lessons.

This study indicated that student teachers have the ability to ask questions but their questioning weakly developed interactions between student teacher and students. The development of student teachers' questioning probably demands active prolonged practice and training in science classrooms as several studies have showed, e.g., [20,21,24,70]. Thus, it is important that the student teachers practice using different question categories with the assistance of the supervising teacher in the training school. In this study, the student teachers' training period was short, and student teachers knew their students only superficially, which may have lessened the interaction and questioning between teacher and students. It is also important that student teachers analyze and investigate their questioning after inquiry lessons with a supervising teacher, which may advance and develop questioning skills.

As student teachers often asked factual knowledge in this study; a teacher's orientation toward inquiry teaching and questioning may be in relation to a teacher's pedagogical content knowledge (PCK) and teaching practice, such as Chan and Yung [60] have mentioned that making teachers more aware of their routine responses as well as the possible alternative ways of dealing with critical moments can better prepare teachers for on-site pedagogical content knowledge (PCK) development in their future encounters of similar situations. Student teachers also avoided an explicit evaluation of students, acknowledged students' contributions and developed questions based on students' prior responses, which may lead, to some extent, to more deep questioning between student teachers and students as found in prior research [18].

5. Conclusions and Limitations

In this study, student teachers' questioning was studied in primary and in secondary school levels and elicited new insights, especially during different inquiry stages. The results showed that the student teachers mainly asked questions about facts and definition of

concepts, which weakly scaffolded students' understanding during inquiry-based biology lessons. Conversely, it is presumably challenging for student teachers to generate or use higher-order questions such as analyzing, synthesizing, and evaluating questions during inquiries. Development of student teachers' questioning demands, probably, prolonged practice and critical interaction between teacher and students, as study of pedagogical content knowledge (PCK) indicates. The student teachers' questioning skills are important during all inquiry stages of lessons, but especially in the examination and the conclusion stages, the significance of questions emphasizes teachers and students to deepen their understanding in lessons.

The results of this study revealed that student teachers used questioning in inquiry-based lessons and asked many questions, but there is still a need to practice and develop student teachers' questioning more toward higher-order questioning and further toward a greater understanding of questioning. Student teachers paid attention to students' questions and views but student teachers could develop interactive discourse between student teacher and students. It is important that student teachers practice and analyze interactive discourse in inquiry lesson.

The interaction between teacher and students is valuable and significant in inquiries, which presumably leads gradually toward a deeper understanding and development of teacher questioning. A better understanding of question-generation may advance knowledge on how to foster student teachers' higher-order questioning both in primary and in secondary school level during the teacher training period. It is fruitful to study the student teachers' questioning at primary and secondary school levels, and teachers' and students' inquiry practices can be seen as continuously progress through primary and secondary school, such that the development of the teachers' questioning skills demands, arguably, a prolonged period.

Video data act as a valuable source of information about student teachers' questioning and speaking. Moreover, video recordings make it possible to examine student teachers' questioning in an authentic space, which is crucial for the development of teacher questioning. The sample size of video recording of student teachers in this study was relatively limited, and the findings cannot be generalized. The student teachers' lessons were video-recorded only in one training school, which may limit the conclusions. Furthermore, it was a challenge to find suitable question categories for analysis of student teachers questioning, especially question categories that are specifically significant in inquiry-based biology lessons. To be clear, this study concentrated only on student teacher questioning, and students' questions or their learning activities have not been studied.

The implication of this study for teacher education is that teaching programs need to make student teachers aware of the skill of questioning, especially during inquiry-based activities. This study can provide a starting point and a new step for the development of student teacher questioning in inquiry-based biology lessons. However, more research and understanding are needed on how to develop student teacher questioning, especially higher-order questioning, in student teacher education.

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