Measuring Didactical Competencies for Informatics Education among Prospective Primary School Teachers

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Abstract. Even primary school children live in a world that is permeated by informatics. Therefore, they need informatics competencies in order to be able to understand and help shape this world. To enable the acquisition of informatics competencies in primary school, informatics-competent primary school teachers are essential. In addition to informatics competencies, they also need the didactical competencies to teach informatics in a way that is appropriate for the subject, the child, and the purpose. This article presents a way to measure didactical informatics competencies. Self-assessment items are used to measure participants' self-perceived didactical informatics competencies pre and post seminar participation. Reflection sheets are used to support reflection on the developed lesson plans, including assessment of target group orientation, informatics relevance, and professional correctness.

Keywords: Informatics education · Prospective primary school teachers · Didactical competencies

1 Motivation and Introduction

Both the Committee on European Computing Education [1] and the European Commission within the Digital Education Action Plan 2021-2027 [4] advocate continuous informatics education for all students, starting in primary school. For this to be implemented, informatics education needs to be integrated into primary school teacher training [13, 5]. Therefore, prospective primary school teachers not only need informatics competencies by themselves but also competencies in teaching them. According to [20], didactical competencies refer to the question of how learning processes can be promoted and supported. In particular, it is about good quality tasks, explanations, and representations. The model of didactic reconstruction for informatics described in [2] includes, among other components, the capture of teachers' perspectives.

In order to enable prospective primary school teachers to develop didactical informatics competencies, courses are designed and offered explicitly for this purpose at various university locations. In a seminar at the PH Schwyz for prospective primary school teachers focusing on data structures, algorithms

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(incl. block-based programming) and informatics systems [3], the development of didactical informatics competencies is supported through the use of teaching examples. In a seminar on informatics for primary school at the University of Wuppertal offered for prospective primary school teachers [7], not only existing teaching materials are tested but the participants also develop their own informatics-specific lesson plans (LP). The participants test these with each other in the seminar and reflect on them together. In seminars of a collaborative project in North Rhine-Westphalia for prospective primary school teachers for science [11], the developed LP are implemented by the participants with primary school children. The experiences of the participants are reflected upon cooperatively. At TUD Dresden University of Technology the seminar "Informatics education in primary schools" [19] was designed that combines good approaches of the described courses. For this seminar, previously existing and in the seminar acquired didactical informatics competencies should be measured[3]. Until now, there is no informatics-specific measuring instrument for didactical competencies.

This article presents a possible instrument for measuring didactical informatics competencies. Chapter 2 addresses the research question and design before exemplary results are presented and discussed in chapter 3. In both cases, the self-assessment questionnaire and the reflection sheet on the developed LP are considered. Chapter 4 on limitations and outlook closes the article.

2 Research Question and Design

In order to address the research question "*How can didactical informatics competencies of prospective primary school teachers be assessed?*", an instrument consisting of a self-assessment questionnaire and a reflection sheet for the developed LP was designed. It was used for the first time in a seminar on informatics education in primary schools, in which prospective primary school teachers acquire both professional and didactical informatics competencies (see Fig. 1).

2.1 Self-Assessment Questionnaire

The developed self-assessment questionnaire consists of eleven items (see Tab. 1 in the appendix), which are rated on a 5-point Likert scale (1: strongly disagree to 5: strongly agree) before the start of the seminar and after the discussion of the LP (see Fig. 1). Eight self-assessment items (SA1–SA8) were formulated based on competency formulations in the standards for teacher education of the Standing Conference of the Ministers of Education and Cultural Affairs [12, p. 9]. These were supplemented by three items on confidence in SA9: elaborating informatics content together with primary school students, SA10: the excitement of primary school students for informatics content, and SA11: the answering of individual questions about informatics content, taken from [9] with slight adaptions. In

[3] In order to also measure subject-specific informatics competencies, another measurement instrument was developed, which is explained in more detail in [18].

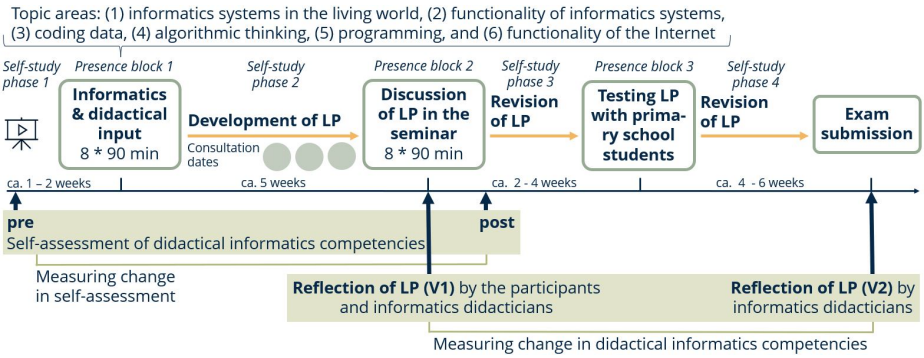

Fig. 1. Structure of the seminar on informatics education in primary school

order to establish a reference to concrete informatics contents, the self-assessment items SA9, SA10 and SA11 are queried for the six topic areas based on the recommendations of the German Informatics Society [6]: (1) informatics systems in the living world, (2) functionality of informatics systems, (3) coding data, (4) algorithmic thinking, (5) programming, and (6) functionality of the Internet. Here, the participants can only indicate whether they are confident in the self-assessment item related to the respective topic area.

2.2 Reflection Sheet for Developed LP

To improve one's own teaching competencies, lesson observations with subsequent reflections are an important foundation [10]. Based on [8] and [17], a reflection sheet with eleven items was created to survey the didactical informatics competencies (see Tab. 2 in the appendix). In order to use the reflection sheet, the prospective primary school teachers have to create informatics-specific LP, which they present to one another, then test parts and reflect on them cooperatively in the seminar. To develop these eleven items, existing statements in literature were modified or supplemented with regard to the specifics of informatics. The reflection sheet is used by the prospective primary school teachers and the informatics didacticians to rate the LP on a five-point Likert scale (1: strongly disagree to 5: strongly agree). The participants use the reflection sheet after the presentation and the testing of a part of the LP with the other participants for a peer feedback (example item: The teacher focused on informatics-specific content in the lesson.). The informatics didacticians use the reflection sheet for the evaluation of the LP (tabular plan and first materials) without further explanation (example item: The LP focuses on informatics-specific content.). In the first step, each informatics didactician comments on all eleven items for each LP, and rates them on the scale. After the didacticians have done this independently, they discuss their assessments with each other and agree on a value on the scale. This applies to version 1 (V1) and the revised version 2 (V2). The assessment of the revised versions will take place approximately three months after rating V1.

There is no direct comparison with V1. The assessments of V1 and V2 are compared in order to detect possible changes in the students' individual didactical informatics competencies. Fig. 1 shows the measurement times.

3 Exemplary Results and Discussion

The instrument for measuring didactical informatics competencies has been used in the elective seminar since the winter semester 2021/22. A total of $N = 19$ data sets were collected. Prospective primary school teachers from the 3rd semester or higher participated. Four of these indicated that they had already participated in informatics education courses. Two further participants stated to have educated themselves individually through their own research. In the following, first, the results of the self-assessment questionnaire and then those of the reflection sheet for the developed LP are presented and discussed.

3.1 Exemplary Results on the Self-Assessment Questionnaire

In the pre-post comparison of the participants' self-assessment of didactical informatics competencies (see Fig. 2), significant changes are shown for all eleven items (exact significance (2-sided) ≤ 0.05). The largest changes are shown in SA5: knowledge of material ($\Delta A = 2.68$) and SA7: development of concepts to enable informatics education ($\Delta A = 2.53$). This can be explained by the fact that many already existing materials are presented and tested within the input phase of the seminar. Developing concepts for informatics education is also a focus of the seminar. With average values of 3.68, the participants already estimate before the seminar SA2: importance of informatics education as well as SA10: their confidence in relation to the excitement of students for informatics contents to be high. Thus, the changes are small with 0.53 and 0.84. The high pre value of the importance of informatics education in primary school can be explained by the fact that it is an elective seminar and the prospective primary school teachers freely chose from various elective options. Between participants without and with informatics education, the greatest differences are evident in the items SA3: connection to current curricula ($\Delta A = 1.17$), and SA5: knowledge of material ($\Delta A = 1.06$) prior to participation in the seminar, with the average values of those with prior knowledge being higher in each case. Participants' self-assessments after the seminar differed little between these two groups.

When participants assessed whether they were confident in SA9: elaborating the informatics content, SA10: exciting students, and SA11: answering individual questions (see Fig. 3), significant changes were found in the pre-post design for the topic areas of (2) functionality of informatics systems, (3) coding data, and (4) algorithmic thinking. For the topic area (1) informatics systems in the living world, significant changes were found for SA11: answering questions, and for the topic area (5) programming, significant changes were found for SA9: elaborating the informatics content and SA10: exciting primary school students. For the topic area (6) functionality of the Internet, participants' confidence of

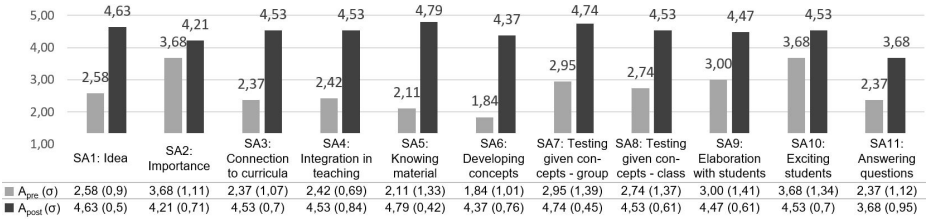

Fig. 2. Pre-post comparison of participants' self-assessment of didactical informatics competencies. $N = 19$

all three items (SA9, SA10, SA11) actually decreased. This could indicate that, prior to participating in the seminar, the participants associated media literacy competencies such as using the Internet with this topic area, indicating a misconception. In this case, the acquired informatics competency could have led to the participants being less confident in this topic area after participating in the seminar.

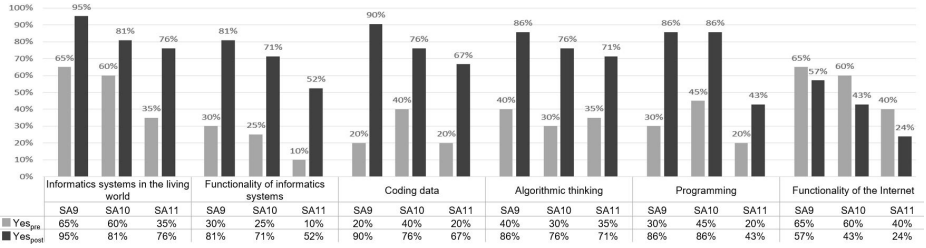

Fig. 3. Pre-post comparison of participants' self-assessment of didactical informatics competencies SA9, SA10 and SA11 for six informatics topic areas. $N = 19$

Furthermore, it is remarkable that the participants already assess themselves with rather good values for SA9 ($A_{pre} = 3.00$) and SA10 ($A_{pre} = 3.68$) for informatics contents in general prior to the seminar. This could be related to the fact that participants are more likely to associate these items with talking about informatics and may also have misconceptions about informatics (e. g., equating it with media literacy). The participants are much less confident in answering individual questions about informatics content (SA11; $A_{pre} = 2,37$). This could indicate that the participants perceive more informatics competencies as necessary here than in SA9 and SA10. Looking at the confidence for the six topic areas prior to the seminar, less than 50% of the participants are confident in SA9, SA10 and SA11 for (2) functionality of informatics systems, (3) coding data, (4) algorithmic thinking, (5) programming. This could indicate, when asked about their confidence in more concrete informatics topic areas, doubts seem to arise.

3.2 Exemplary Results on the Reflection Sheet for Developed LP

The assessment of V1 of the LP by the informatics didacticians shows deficits especially for the items concerning RS2: prior knowledge of the primary school children, RS4: comprehensible work assignments, RS9: informatics correct explanation, and RS10: target group oriented explanation. Fig. 4 shows an example of the differences in the assessments of the informatics didacticians of the two versions (V2 – V1) of the LP by three participants. The difference of the evaluation on a 5-point Likert scale (1 - strongly disagree, 5 - strongly agree) is shown. A positive difference is to be interpreted as an increase in competency since the score of V1 is subtracted from that of V2.

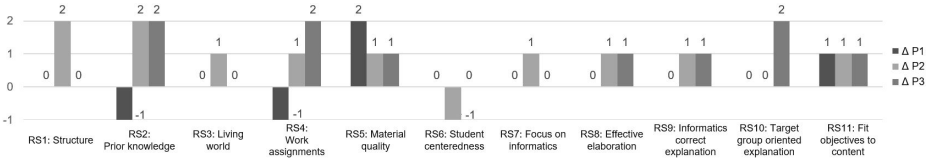

Fig. 4. Differences of the evaluation of the first and revised LP (points V2 - points V1) of three participants (P)

The assessment of the prospective primary school teachers of the LP using the reflection sheet reveals that they generally give rather positive ratings. The deficits of the LP in RS9: informatics correct and RS10: target group oriented explanation, which were pointed out by the informatics didacticians, are not visible in their assessments.

4 Limitations and Outlook

The self-assessment questionnaire of didactical informatics competencies was applied successfully. However, this could only be tested with prospective primary school teachers who voluntarily chose to attend the seminar. Therefore, it is not a representative sample of all prospective primary school teachers. Furthermore, misconceptions, as they have been shown in the experiences of the seminars at the PH Schwyz [3] and the University of Wuppertal [7] (see chapter 1), about the term informatics and the terms in the naming of the topic areas influence the self-assessment of the participants.

The presented reflection sheet can only partially be used to measure didactical informatics competencies. The peer feedback collected with the reflection sheet has no added value for the survey of the didactical informatics competencies because the participants hardly recognized the weaknesses in the LP of the others and generally evaluated them very positively. It cannot be used as a research tool, but it is didactically useful for application in teaching. In addition,

the peer feedback by the participants and the feedback by the informatics didacticians are not comparable, since the formats of the survey are very different from each other. The informatics didacticians provide their feedback only on the LP that are available in tabular form. The participants of the seminar also look into the tabular documents, can ask questions to the presenting participants and often have more or revised materials available. By asking questions or the expression of comments by individual participants in the presence of the whole group, all participants may be influenced in their evaluation of the LP. In the use of the reflection sheet by the informatics didacticians in the assessment of the V1, limitations arose from the fact that the participants did not always follow the instructions for the preparation of the LP. If, e. g., the work assignments and informatics explanations were not provided or specified, the LP could only be assessed inadequately or not at all with regard to the items on these topics. The same applies to the learning materials.

The items of the reflection sheet are partly difficult to evaluate on the five-point Likert scale. Here, item-specific formulations describing the respective levels could be helpful. The use of the reflection sheet enables the consideration of the same criteria for the assessment of the developed LP from the perspective of the informatics didacticians and the participants.

For testing the LP revised by the prospective primary school teachers with primary school students as a real teaching-learning scenario like in the seminars of a collaborative project in North Rhine-Westphalia [11] (see chapter 1), a feedback sheet has already been developed on which the primary school students can evaluate the lesson. For this, statements from [15] were selected, which are supplemented by one or two informatics learning objectives of the respective LP. The seminar leader participates in the tests and uses the reflection sheet to assess the observed lesson. Through the extension, it can be checked whether the informatics competencies can be elaborated by the participants together with the primary school students.

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A Appendix

Table 1. Items for the self-assessment questionnaire of didactical informatics competencies

Self-assessment items SA1 – 8 (based on competency formulations in the standards for teacher education of the Standing Conference of the Ministers of Education and Cultural Affairs [12, p. 9])	
SA1:	I have an idea of what content and concepts informatics education encompasses.
SA2:	The teaching of informatics competencies is of great importance to me.
SA3:	I know points of contact for informatics content and competencies in current primary school curricula.
SA4:	I have an idea of how to integrate informatics education into my teaching.
SA5:	I can draw from a selection of existing materials for the implementation of informatics education in primary school.
SA6:	I can develop teaching-learning concepts that enable informatics education for primary school students.
SA7:	I have the confidence to test given teaching-learning concepts with a small group (max. ten participants) that enable informatics education for primary school students.
SA8:	I have the confidence to test given teaching-learning concepts with a class that enable informatics education for primary school students.
Self-assessment items SA9 – 11 (slightly adapted taken from [9])	
SA9:	I am confident in my ability to work with primary school students to develop informatics content and skills.
SA10:	I am confident in my ability to get primary school students excited about informatics content.
SA11:	I have the confidence to answer primary school students' individual questions about informatics content.

Table 2. Items of the reflection sheet (RS) for developed lesson plans (LP) including the source (S) it is inspired by

Nr.	Item - informatics didacticians	Item - participants	S
RS1	The LP is clearly structured.	The teacher structured the lesson clearly.	[8]
RS2	The LP actively links to the students' previous experiences and knowledge.	–	[17]
RS3	The LP contains examples from the everyday life of the primary school students and/or ties in with the interests of the primary school students.	The teacher integrated examples from the everyday life of the primary school students and/or ties in with the interests of the primary school students.	[8]
RS4	In the LP, the work assignments are formulated in a way that is understandable for primary school students.	The teacher formulated the work assignments in a way that is understandable for primary school students.	[17]
RS5	The materials used in the LP are designed in a way that is appealing to and understandable for primary school students.	The teacher designed the materials in a way that is appealing to and understandable for primary school students.	[17]
RS6	The LP is student-centered and activating.	The teacher designed the lesson in a student-centered and activating way.	[17]
RS7	The LP focuses on informatics-specific content	The teacher focused on informatics-specific content in the lesson.	[16]
RS8	In the LP, the informatics-specific subject matter is effectively developed with the primary school students.	The teacher developed the informatics specific subject matter with the primary school students in an effective manner.	[14]
RS9	In the LP, the informatics-specific subject matter is explained correctly.	The teacher explained the subject matter correctly.	[14, 16]
RS10	The LP explains the informatics-specific subject matter in a way that is appropriate for primary school students.	The teacher explained the informatics-specific subject matter in a way that is appropriate for primary school students.	[14]
RS11	In the LP, the informatics-specific content is prepared according to the formulated learning objectives.	–	[14]