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Promoting Teacher Students' System Competence by the Development of a Syndrome Approach in an Interdisciplinary Seminar

Nicklas Müller[1], Doris Elster[2]

Abstract

The cross-linkages in our globalised world are becoming more and more complex. To be able to unravel these interconnections and to take part in the processes of sustainable development the promotion of the system competence in teacher education is highly relevant. The syndrome approach is a tool developed by the German Advisory Council on Global Chang) to analyse the system structure and determine unsustainable developments and environmental problems in earth systems.
The "INQUIRE for Teacher Students" course is an academic training program for biology teacher candidates. The goals of the course are the promotion of teacher candidates' system competence and the development of their content knowledge in respect to the biodiversity loss and climate change in the German Wadden Sea. Therefore, the teacher candidates develop complex syndrome approaches (visual representations) and refine them during the course run. In addition, the teacher candidates develop complex simulation games for pupils of the secondary level and measure the impact of these games on the pupils' system competence and content knowledge.
In winter 2016 22 biology teacher candidates participate in the INQUIRE course. Data are collected via interviews, questionnaires (pre-post-design) and graphical representations (concept-maps and syndrome approaches). The analysis of the qualitative data is based on the paradigm of the qualitative content analyses. The graphical representations are analysed quantitatively.
The results demonstrate an increase of the teacher candidates' content knowledge and system competence. We think that the syndrome approach is a fruitful method to promote teacher candidates' interdisciplinary thinking.

Keywords: *training program, biology, INQUIRE, teaching;*

1. Relevance of the system competence

The promotion of the system competence is an essential element of the Education of Sustainable Development (ESD). This competence helps pupils to comprehend and unravel the complex and cross-linked relationships in the globalised world [1]. Mehren et al. [2] define system competence as the ability to understand, to describe and to model the organisation and the functions of a complex area of reality (dimension 1) and to make predictions and regulatory measures for the exploitation and regulation of systems (dimension 2). Both dimensions can be divided in three levels and consist of more subdimensions [6].

1.1 Promotion of the system competence

Empirical studies show that the system competence can be trained with appropriate learning activities in socio-scientific contexts [3], [4], [5], [6]. Besides conducting and especially developing simulation games, the work with the syndrome approach is an appropriate method to foster the system competence [7], [8].
In addition to the learners' interest and the pre-knowledge, there is a strong correlation between the teachers' influence and the pupils' system competence [9]. Therefore teachers and teacher candidates should have a well-developed system competence by themselves and the knowledge how to promote this competence.

2. INQUIRE for Teacher Students"

The course "INQUIRE for Teacher Students" is an academic training program for secondary level teacher candidates. The objectives of the course are the development of system competence, content knowledge and methodological knowledge in respect to an Education for Sustainable Development (ESD) [10].

[1] Institute of Science Education, Department Biology Education, Bremen, Germany
[2] Institute of Science Education, Department Biology Education, Bremen, Germany

22 teacher candidates took part in the “INQUIRE for Teacher Students” seminar in the winter term 2016/17. In this seminar they gained practical skills about inquiry-based science education and received information on the German Wadden Sea. The focus was set on the context of climate change and its effects on biodiversity. To explore the impact of climate change, the whole project was covered by the syndrome approach. The teacher candidates developed in small groups on four different dates their own syndrome approach by incorporating their new knowledge.
They applied their new content and methodological knowledge by developing complex simulations games for school classes. They conducted the simulation games with the classes and evaluated the gain of pupils’ content knowledge and system competence (figure 1).

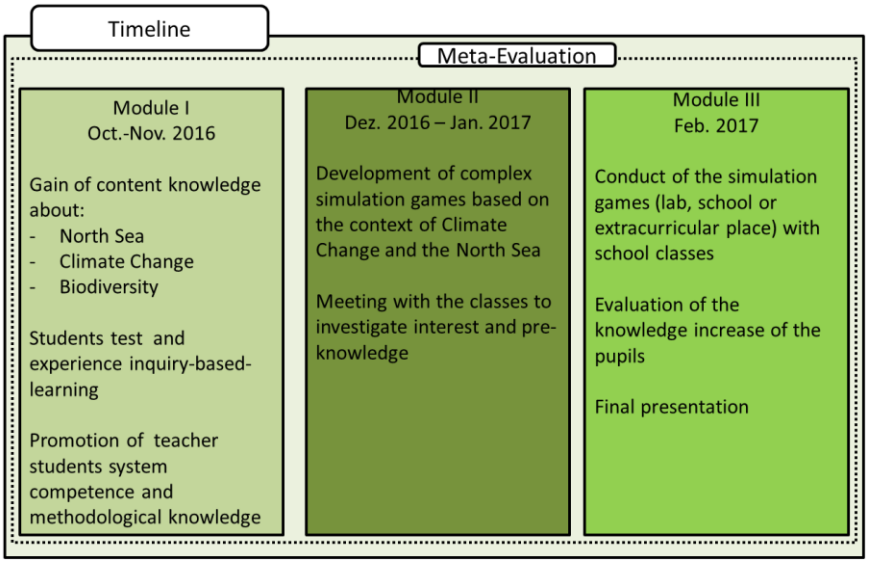

Figure 1: Timeline of the training program “INQUIRE for Teacher Students”

2.2 Syndrome approach

The syndrome approach was developed by the German Advisory Council on Global Change [11]. This approach is a tool to determine unsustainable developments and environmental problems in earth systems, by regarding them as a syndrome. It is presumed that the global change is based on a manageable number of cause-and-effect-interactions in the man-environment relationship, which are called symptoms. To analyse the syndromes, the symptoms are connected in a cause-and-effect-diagram with reinforcing and extenuating connections. During the derivation of the syndrome-interconnectedness, step by step sustainable plans and arrangements for the syndrome regulation are developed [11]. Describing the typical problem-causing environment-degradation-patterns of the Global Environmental Change the syndrome approach is an appropriate method to foster interdisciplinary thinking and acting of the learners [12].
During the seminar the candidates analysed in four groups the local syndrome “Impact of climate change on biodiversity in the German Wadden Sea” by trying to connect all elements of this system (like CO_2- emission, increasing greenhouse effect, change of salinity etc.) to identify unsustainable developments.

3. Research questions

The project aims at evaluating teacher candidates’ content knowledge, their system competence and the professional development of the candidates based on the “Pedagogical Content Knowledge“ (PCK) model. [The evaluation of the teacher candidates’ PCK is not part of this paper.]

4. Research design

The INQUIRE for Teacher Students course was investigated by a meta-evaluation. The data were collected via interviews, questionnaires (pre-post-design), which included the development of concept-maps, and developed syndrome approaches (figure 2). To preclude that the arise of content knowledge is the reason for an improvement of the concept-maps from pre to post test, the concept

maps have been developed about a topic which was not part of the course. The participants were given short text about the ecosystem of a forest, which they had to transfer into a concept map.
The interviews and the open questions from the questionnaire were encoded following the qualitative content analysis of Mayring [13]. The graphical diagrams were analysed quantitatively based on their basic structure [14], range (all elements + connection) [5], structural index (SX=all element-chains + loops + forks divided by all Elements) [15] and connection index (VX=double number of connection dived by all elements) [4].

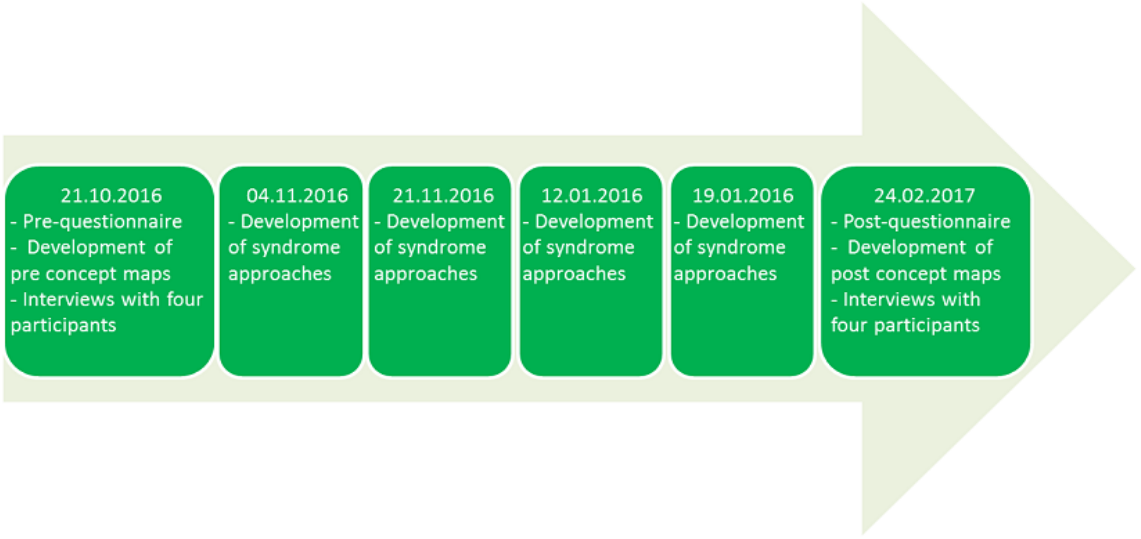

Figure 2: Timeline of the research

5. Findings

5.1 Content knowledge

The content knowledge of the participants increased significantly. The questionnaire contains 4 content knowledge items related to the topics “Biodiversity”, “Climate Change” and “Impacts of climate change on biological diversity in the Wadden Sea” and a maximum score of 25 can be reached. The average score increased significantly (p=.001) from 4.7 (pre-test) to 7.0 (post-test).

5.2 System competence

5.2.1 Concept maps

The complexity of the concept maps increased clearly (cf. figure 3). The number of placed elements rarely increased (Ø pre E= 13.0, Ø post E=13.9), but the participants used a lot more interconnections to connect these elements (Ø pre R= 12.1, Ø post R=19.8). Therefore the connection index also increased (Pre-VX=2.0; Post-VX=2.7). The structural index shows that the complexity of the interconnections (forks, chains & loops) improved from pre- to post-test (Pre-SX= 0.4; Post-SX=0.6). But despite an extended method training the concept maps contain a lot of methodical mistakes. Many participants integrated features of the syndrome approach, like reinforcing or extenuating connection without describing them.

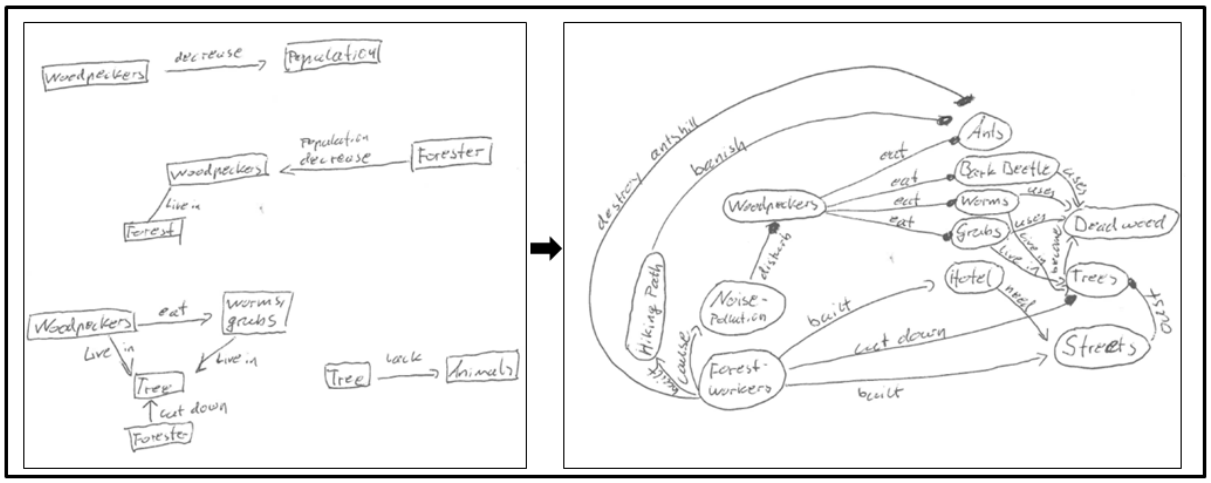

Figure 3: Translated Pre & Post Concept Map of a participant

5.2.2 Syndrome approach

All groups are able to develop complex syndrome approaches (table 1) (Ø E=41.6, Ø R=64, VX=3.1, Ø SX=0.7). But only group 1 reduces the complexity of the system by generalizing some aspects, to create a model of the reality which illustrates the most important relationships in the system. All other groups placed a lot more details, which results in a confusing and unorganized syndrome approach. All five approaches contain more elements and connection then the sample solution (E=30, R=48, VX=3.2, SX=0.9). But none of the approaches contain an element-chain (three or more elements connected in the same direction without a fork).

It is noticeable that the groups on the first develop date only incorporated elements without connecting them in their paper and pencil syndrome approach. From the second date they start to connect the placed elements without adding a lot of new elements.

Table 1: Evaluation of the syndrome approaches

Group & Date		Elements	Connections	Range	Forks	Loops	Chains	VX	SX
1	1. Date	24	19	43	9	1	0	1,58	0,42
	2. Date	32	55	87	26	2	0	3,44	0,88
	3. Date	32	55	87	26	2	0	3,44	0,88
	4. Date	34	64	98	30	2	0	3,76	0,94
2	1. Date	26	0	26	0	0	0	0,00	0,00
	2. Date	44	46	90	15	0	0	2,09	0,34
	3. Date	46	52	98	20	0	0	2,26	0,43
	4. Date	50	68	118	25	1	0	2,72	0,52
3	1. Date	19	33	52	17	2	0	3,47	1,00
	2. Date	30	52	82	26	2	0	3,47	0,93
	3. Date	30	52	82	26	2	0	3,47	0,93
	4. Date	30	52	82	26	2	0	3,47	0,93
4	1. Date	30	0	30	0	0	0	0,00	0,00
	2. Date	47	30	77	13	0	0	1,28	0,28
	3. Date	47	53	100	19	1	0	2,26	0,43
	4. Date	47	58	105	24	1	0	2,47	0,53
5	1. Date	39	4	43	0	0	0	0,21	0,00
	2. Date	59	17	76	6	0	0	0,58	0,10
	3. Date	56	44	100	10	1	0	1,57	0,20
	4. Date	47	78	125	33	1	0	3,32	0,72
Sample Solution		30	48	78	26	1	0	3,20	0,90

6. Discussion and conclusions

The findings demonstrate that the “INQUIRE for Teacher Students” had a positive influence on the teacher candidates´ content knowledge and their system competence.

The almost consistent number of elements in the concept maps demonstrates that the participants were capable to figure out the important components of the forests ecosystem before the course. But during the course they improve their ability to identify the relationships between these elements and to present them. The large number of methodical mistakes despite a method training has been ascertained in earlier studies were two different graphic representations methods were applied. This leads us to the conclusion to use only one method in the follow up courses.

The missing of element-chains and the high indices in the syndrome approaches shows that the participants were able to find a large number of interconnections in the Wadden Sea System. But only one group reduces the complexity of the reality to a great extent. But exactly this complexity reduction of the real world to unravel the cross-linkages in our globalised world is a core skill of the system competence. Nevertheless all participants are convinced that the development of the syndrome approach helped them to understand and describe the system “Impact of climate change on biodiversity in the German Wadden Sea” (M=4.0 on a Likert scale of 1-5, SD=1.0).

The missing connections in the syndrome approaches after the first develop date can be explained by a hesitation to fix the first idea of a syndrome approach with a pencil on the paper. 17 out of 22 participants would prefer a digital version of the syndrome approach to be more flexible. Therefore the development of digital syndrome approaches is in the focus of attention in the follow up courses.

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