New Perspectives in Science Education
International Conference
NEW PERSPECTIVES in SCIENCE EDUCATION
5th Edition

PROMOTING SYSTEM THINKING VIA THE SYNDROM APPROACH

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Abstract
The syndrome approach developed by the German Advisory Council on Global Change [1] is an analysis tool for identifying unsustainable developments and environmental problems in earth systems by considering them as disease patterns, the syndromes of global change. The syndrome approach aims to reduce complex environmental problems to distinct relations between system elements in a cause-and-effect-interaction [2].
Based on the context of climate change and the challenges of biodiversity loss two scenarios are selected to analyze a complex environmental syndrome: 1) the climate forced human migration in Oceania and 2) the dramatically loss of the lobster population around the North Atlantic Island Helgoland. For both scenarios teacher students of the University Bremen develop complex simulation games based on the syndrome approach. They conduct these games with school classes and evaluated pupils' system thinking [3] and decision making regarding environmental problems [4]. The findings demonstrate the high potential of the syndrome approach as a motor for an education for sustainable development (ESD) and to persuade students to participate in a formation of an ecologically compatible, economically efficient and socially suitable society.

1. System competence as a key competence of the 21st century
Education for sustainable development (ESD) as an interdisciplinary educational objective focuses on the promotion of competences students are needing for the sustainable societal partake [5]. It is assumed that learners can partake in the discussion of challenges of sustainable development if they are trained in system analysis and system thinking in the context of global issues.
[2], [4]. According to Rempfler & Uphues [2] the system competence is based on the following sub-competences: 1) the ability to describe system in their structure and organization (dimension 1); 2) the ability to analyse functions and behaviour (dimension 2); and 3) the ability to predict and act system adequately (dimension 3). In a school-practical application these three dimensions are divided in three levels. The levels are based on two complexity features: the number of elements (low, medium, high) and the degree of interconnectedness (mono-causal, linear, complex) [2].

1.1 Fostering system competences
Based on empirical research the learners' system competence can be trained with appropriate learning activities in socio-scientific contexts [3], [6], [7]. There is a direct correlation between the learner's interest and pre-knowledge, the teacher's influence and the system competence [3], [6], [8]. In this context the visualisation of the flow path and graphic representations of complex interconnections are of great importance [6], [7,].

1.2 Syndrome approach
Syndromes are patterns of problematic human-environment-interconnections represented by relations between the natural and the anthropogenic shaped sphere of the earth system [10]. The approach is divided in the dimension of analysis of the system and the dimension of acting system adequately. Starting with the derivation of a syndrome-interconnectedness based on reinforcing and extenuating relations within local and global trends, step by step sustainable plans and arrangements for the syndrome regulation are developed [1]. 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 at school [9]. Within our study two activities are developed based on the syndrome approach. They are a sort of simulation games and the students' task is to analyze the specific syndrome and to develop action plans how to act sustainable to overcome the syndrome.
Syndrome "Climate forced migration in Oceania"
Tuvalu is small state in the Pacific. It consists of nine small islands, most of them atolls that are coral reefs with a laguna in the middle. Most of the houses, infra structure and economic activities are near

the coasts. The surrounding ocean is determining the life of the inhabitants of Tuvalu. Based on an intensive literature research and experiments the students analyze in teams the syndrome of climate forced migration caused by local socio-economic problems (like lacking of tap water, waste disposal, diseases) and recent changes of the natural environment caused by climate warming (like the increase of the sea level, erosion and flooding). They try to develop solutions and action plans to overcome the problematic of the loss of home and identity.

Syndrome "Biodiversity loss in the North Sea"

The European lobster is one of the heraldic animals of Helgoland, an island in the North Sea. In former days the lobster fishing was one of the main income sources of the Helgoland inhabitants. Since the 2nd World War the lobster population has dramatically decreased, nowadays the lobster is in danger of extinction. The students analyze the syndrome from an ecological, economical and political-historical perspective. They develop and discuss action plans about the resettlement and the conversation of this endangered species.

2. Research questions

The evaluation of the syndromes focuses on 1) students' interest and pre-knowledge in respect to the specific syndrome; 2) students' system organisation (dimension of system adequate analysis); 3) students' system-adequate acting (dimension of system adequate acting); 4) evaluation of the method syndrome approach.

3. Research design

The 4-hours lasting activities were conducted with 8th-10th Graders (N=162) in the outreach lab MARUM at the University of Bremen and the Zoo am Meer in Bremerhaven, Germany. The students worked in teams and solved tasks in connection to the specific syndrome. After each of the six stations the students discussed the elements with respect to the syndrome and sorted the elements according to the dimensions atmosphere and hydrosphere, biosphere, economy and politics, social and society. After the analyses of the syndrome the students connected the system elements to the "syndrome map", a sort of concept map.

During the next step they discussed and developed a list of measures to be taken to overcome the syndrome and presented their suggestions in the plenary event.

The structural complexity of the "syndrome maps" was analyzed based on their structural index [13] and their connection index [3]. In addition a questionnaire (pre-post) was used to measure interest, motivation, knowledge and the syndrome method.

4. Findings and discussion

4. 1 Interest and pre-knowledge

The students' interest and pre-knowledge about aspects of the climate change are in general high in respect to both scenarios. The consequences of climate change for the ocean, the biodiversity and the society are well reflected. These findings are in accordance with several other studies which identified that the basic knowledge and interest in contexts of climate change and biodiversity are high [11], [12].

4.2 Dimension "system analysis"

The results demonstrate at the level of the micro-concepts (atmosphere, hydrosphere, society), that most of the graphic system-representations have a reticulated structure. This is in agreement with the identification of elements of the system-structure. In average 11 branches pro syndrome are identified. Furthermore, the reticulation is mirrored in the indices: each element in the syndrome is in average connected with 1,6 relations (VX). The structure index is in average higher than zero (SX=0.37) as a result of complex interconnections (reticulations, chains, circuits).

The graphic representations are in disagreement with the verbal representations. More than the half of the students used linear argumentation structures to interpret at the system dynamic. A complex argumentation structure is only presented in 17% of the cases.

In the discussion about the use of the syndrome approach in the schools its potential of the systemic representations via concept mapping is highlighted [13]. It triggers the process from mono-causal and linear thinking to a more complex thinking structure [14]. This is in agreement with the results in this study.

4.3 Dimension "system acting"

The findings of students' poster-presentations demonstrate a high number of options for acting differed in the categories climate protection, development assistance, costal preservation, education, conservation of species, fundraising compaign, and migration help. All student teams integrated global as well as local perpectives. The switchover of global and local perspectives is a essential component of the system approach and in addition a important concern of the Education of Sustainable Development (ESD) [5].

4.4. Evaluation of the method "syndrome approach"

The syndrome approach is suited to promote interdisciplinary thinking [9]. The findings demonstrate that working in teams to solve a complex environment problem is demanding and promotes the readiness to act. The students valued the evaluation items in the following way: the method "system approach" fosters interest and motivation, is demanding and appealing. Students reported higher order thinking skills to describe system processes, argumentation and discussions.

5. Conclusions

The findings demonstrate that both simulation games promote students' interest in global environmental problems. The syndrome approach is a multidimensional method to analyse complex problems and to develop new dynamic considerations of networking. In addition, the syndrome approach has the potential to initiate an interdisciplinary perspective of the world and to promote sustainable thinking.

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