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An Online Causal Mapping Tool for Environmental Systems Education

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Abstract

Systems thinking is the development of an understanding of how the individual elements of a system interact with each other, thereby influencing each other, and determining the behavior of the system as whole. Causal mapping is used in systems thinking to visualize and educate people on how the different components of the system interact with each other. In this research, we present an online causal mapping tool which can be used for ocean/environmental systems education. The paper contains a review of the existing approaches to the use of system thinking in education and how those approaches compare with our approach. The results of the comparison shows that our tool compares favorably with existing approaches which use system thinking as a basis for education. The tool also has the advantages of being based on an ontology and can be used to link the causal map elements with the contents of an online knowledge base. We also provide an analysis, from an education perspective, regarding the use of the online causal mapping tool to create causal maps of ocean related topics. This analysis reveals how the tool was used to create the causal maps and provides insights into how the causal maps can be improved to make them more educationally beneficial.

Keywords: *Systems thinking, Education, Causal Mapping, Environment, Ocean.*

1. Introduction

The importance of the Ocean to the wellbeing and perhaps even survival of human life on Earth is becoming more and more obvious. As we learn more about the impact we have had on the oceans in a relatively short period of industrialisation, we are faced with a number of challenges such as plastics pollution, acidification, coral bleaching, and of course polar ice melt, to mention but a few. Of course, to fix a problem, you must address the causes of that problem, rather than merely focusing on the symptoms. And to do this, we must understand causes, which can sometimes be a rather complex web of interaction between human and natural activities. This web of interactions must be understood in order to identify those points at which we must intervene for maximum effect. There may be many such points, with different human actors involved at each one. Take for example, the micro-plastics problem. Some plastics enter the oceans through spillage accidents during shipping. Therefore, shipping companies are obvious actors to engage in ensuring their practices minimise such risks. Further up the supply chain, we can look to consumers to choose products which do not contain micro-plastics, thereby reducing the amount that is flushed into the waste water systems, and ultimately ends up in the marine environment. Other actors, such as manufacturers and product developers, can work together to find biodegradable alternatives to plastics for use in everyday products.

The commonly used definition of Ocean Literacy [6], which is to understand "… the influence the ocean has on you and your influence on the ocean" is useful, but ultimately we need to be clear about the meaning of the word "understand" in this context, and push for not just improved understanding, but the modifications in the attitudes and behaviour needed for change. While the Ocean Literacy Framework [7] is useful in categorising the topics and providing a framework for teaching ocean topics, it does not focus to any great extent on the joint human-ocean systems which reveal the real detail behind our interactions with the oceans. To truly influence peoples understanding of their impacts on the oceans, they must have some knowledge of their own and others place and role in the web of interactions. Armed with such knowledge of the systems involved and the cause-and-effect relationships between human activities and natural systems, people are more truly ocean-literate and capable of making informed decisions regarding not just their own behaviour, but also how they communicate on ocean issues with others. The causal maps created by users using the online causal mapping tool are based on the DAPSIWR framework, as shown figure 1.

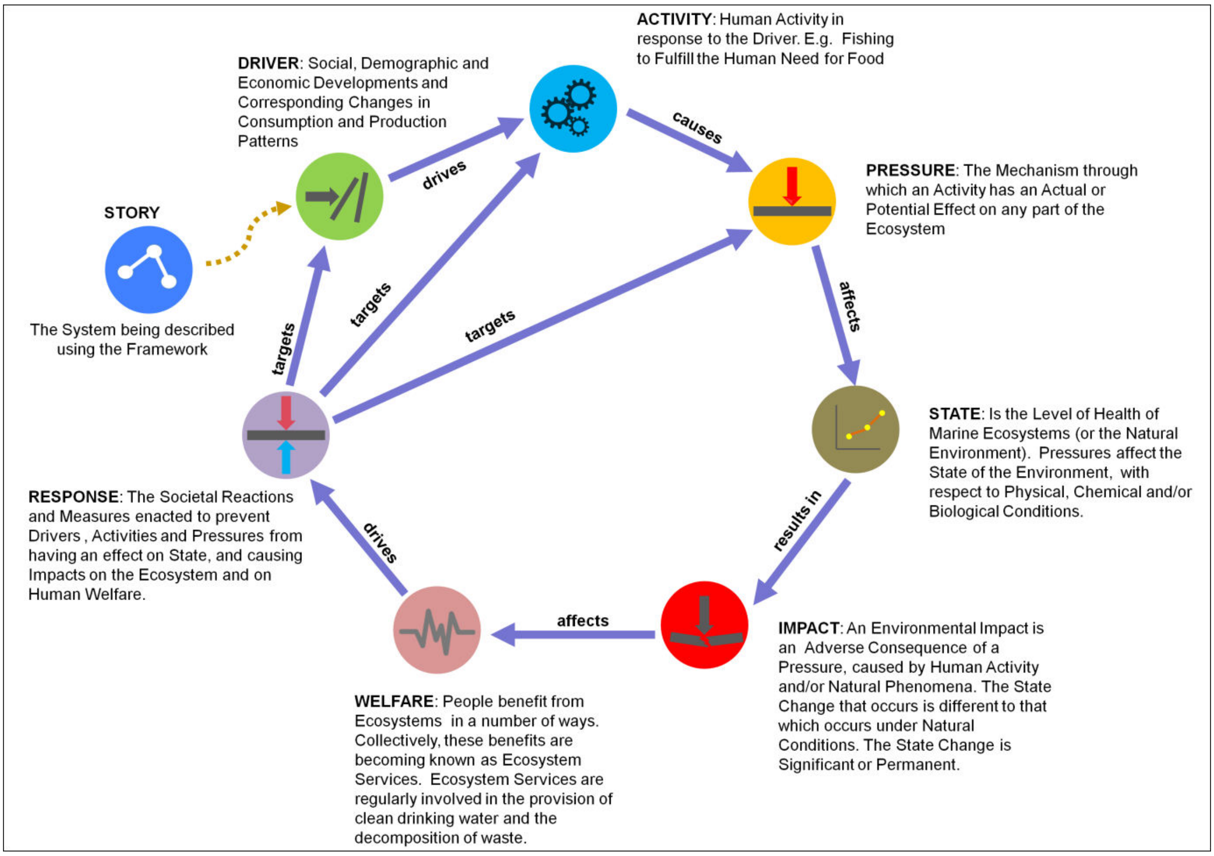

Fig.1. The DAPSIWR Framework [2]

2. Systems thinking in education

The study performed by Brandstädter [1] examined whether particular features of concept mapping practices affected the valid assessment of students' system thinking. The study applied 3 variations of concept mapping practices: (i) highly directed computer mapping, (ii) highly directed paper-pencil mapping, and (iii) non-directed paper-pencil mapping. The concept maps were created using the software package MaNET® and the results showed that the computer-based approach positively influenced student performance in concept mapping when compared with the paper-pencil approach. The purpose of the study performed by Evagorou [3] was to investigate the impact of a simulation-based learning environment on 11-12 years old students' development of system thinking skills. The Stagecast Creator visual programming language was used to simulate the ecosystem of a marsh. Sheehy [8] developed two computer simulations to investigate system thinking and environmental problem solving in children aged between 8 and 11 years. The simulations were computer based and consisted of a generic storyboard into which different problems could be coded. The findings showed that through efficient use of resources and recycling strategies the older children in the study outperformed the younger children.

In research performed by Jeong [5], students constructed causal maps to graphically explain their understanding of how selected factors influence learning in collaborative environments. The students' causal understanding was measured by comparing the causal maps they constructed with the causal map created by the instructor. Urwannachotima [9] used a group model building approach to engage stakeholders in the creation of a causal map of the dynamic interrelationships between a sugar-sweetened beverage tax, sugar consumption, and dental caries. A group of seven dentistry and health professionals developed a causal loop diagram which was then presented and discussed.

A number of online tools exist for creating causal loop diagrams and causal maps. Visual Paradigm Online Diagramming provides an online diagramming tool which allows users to create a causal loop diagram. The left section of the tool allows users to choose from a selection of causal loop diagram elements e.g. Data process, Loop, Start state, Stop state, and Data store. Vensim provides a desktop application for the creation of causal loop diagrams. The Microsoft Visio drawing programme was used by Fairweather [4] to reproduce a digital format version of causal maps drawn by individual farmers.

The causal maps drawn by the farmers were based on how they thought their farm ecosystem worked. The causal connection map data for each farmer was stored in an Excel spread sheet. Kumu is an online tool which allows users to organise complex data into relationship maps which can then be viewed interactively by others. The online causal mapping tool described in this paper is based on an ontology and links the causal map elements with the contents of an online knowledge base.

3. Results and discussion

The purpose of the causal maps created by the users of the online tool was to provide a graphical representation of the elements of an ocean literacy topic, to show the interconnections between the elements, and to input relevant information for the elements of the causal maps. The causal maps are based on the DAPSIWR framework. In this research, we analyse the causal maps to (i) gain an insight into what elements are used to create the causal maps of the topics, (ii) check what information is associated with each of the elements, and (iii) propose ways of improving the causal maps to make them more educationally beneficial.

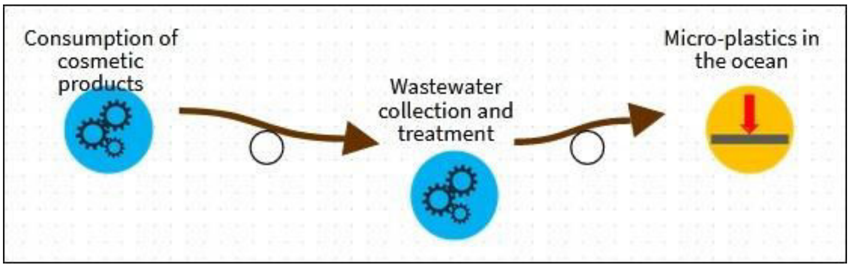

Fig.2. Section of micro-plastics causal map

An example of an educationally beneficial section of the Micro-plastics causal map created using the online causal mapping tool is shown in figure 2. It shows that the Activity: “Consumption of cosmetic products” has an effect on the Activity: “Wastewater collection and treatment” which in turn can lead to the Pressure: “Micro-plastics in the ocean”. In the Coastal Tourism causal map the Drivers identified by the user are Globalisation, Economic structure, and Economic growth which constitutes a more general view of the drivers of coastal tourism. It would improve the educational value of this causal map to be more specific regarding the causal map elements. Examples of more specific drivers of Coastal tourism are “Interest in sun, sea, and sand holidays” and “Economic benefits of tourism.
The information entered by the users into the properties sections of the causal map elements has good educational value. In the properties section of the Driver: “Population variability” in the “Sustainable fisheries and aquaculture” causal map, the user has entered referenced information related to the projected increase in the global population and the extent to which the world’s population depends on seafood for protein intake. An example of where the causal maps could be improved with regard to the information entered into the properties sections is in the case where similar information has been entered for the properties of the Impacts: “Physical and chemical features” and “Habitat – Seabed structure” in the “Sustainable fisheries and aquaculture” causal map. It would be more beneficial to enter information which relates more specifically to the individual impacts.
The causal map created for the topic “Ballast water and invasive alien species” contains a sizeable map of the Actors associated with the topic. Part of the causal map is shown in figure 3. This causal map could be improved by grouping the actors into groups based on how they are involved. An example of a group of actors which could be created is “Shipping Actors” and the Actors which would be attached to the group are “Ship officers”, “Marine equipment manufacturers”, “Industrial manufacturers”, and “Financial & insurance institutions”. Having the actors grouped would help in the situation where the causal map is being viewed by a user who is interested in learning about the different information that is specific to the different types of actors.

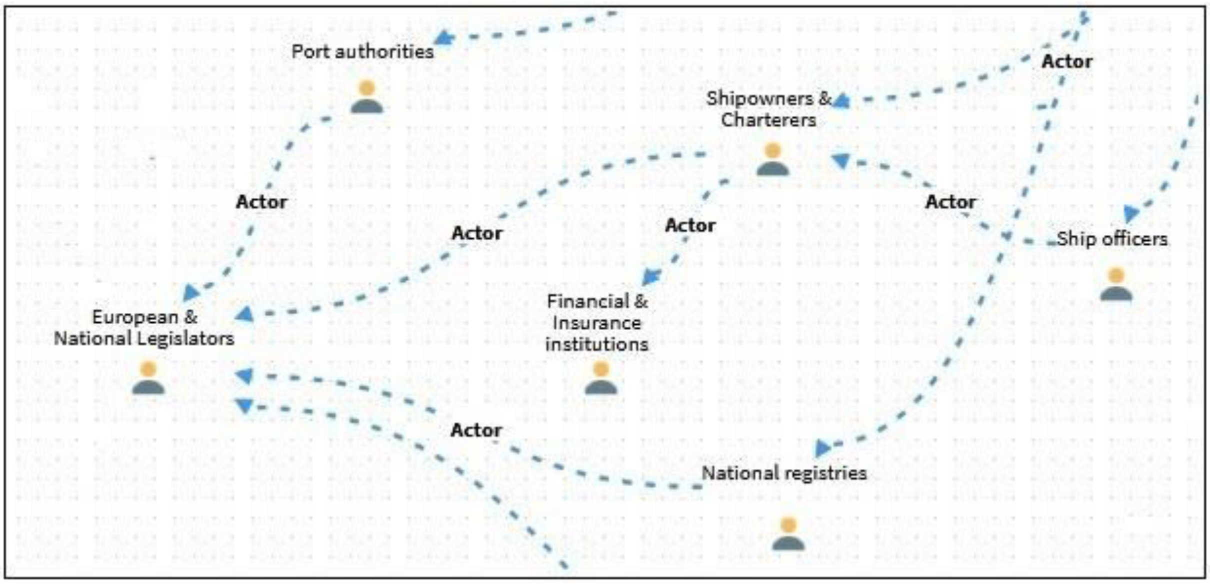

Fig.3. Section of causal map for “Ballast water and invasive alien species” topic

4. Conclusion

The comparison of the online causal mapping tool with existing approaches and tools shows that it is a useful tool which is based on an ontology and allows the causal map elements to be linked with relevant knowledge stored in an online knowledge base. The users of the tool successfully created educationally beneficial causal maps which can be viewed online by people interested in learning about the ocean related topics. In the future, the approach to the creation of the causal maps can be improved by implementing the improvement techniques described in this paper. The techniques can also be applied to the creation of causal maps on other topics related to the ocean and the environment.

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