An advanced form of NetLogo's Forest Fire model: A teaching approach for Primary School students, regarding Complex Systems

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Abstract. In this paper, a teaching intervention is proposed and described. It is methodologically based on the guided inquiry method, while using the modeling, simulation and programming tool of NetLogo. The pre-existing model "Fire" (from the Models' Library of NetLogo) was modified and additional parameters were added such as speed of wind and its direction and the possibility of low humidity. This approach was implemented in a teaching sequence for Primary School students with the main goal for them to understand the basic concepts that govern the "Complex System" of a forest fire, by interacting with the simulation.

Theoretical framework and research questions

NetLogo was created in 1999 by Uri Wilensky and it is a Multi-Agent-based (MAB) modelling, programming and simulation environment for natural and social phenomena [1]. It includes a library of multiple ready-made models and provides the ability to modify the source code by the users. It has been used as an educational tool for teaching complex phenomena known as "Complex Systems" [2] mostly based on the Constructionism knowledge-theory framework [3].

This current work focused on the complex system of a forest fire. The pre-existing model "Fire"[1] has been used - which is a simulation of the spread of a forest fire and it has the density of trees as a parameter. For our own model we relied on the extension "Fire Simple Extension 3" [2] but we improved it by adding to the model the ability to start the fire in the center, the ability to spread the fire with the mouse, and the possibility of low humidity levels. This model is uploaded in the Modeling Commons (NetLogo user's community) with a Greek[3] and an English version[4].

Our goal is for students to understand the basic concepts that govern the "complex" fire system, such as the unpredictability and non-repeatability of fire [1]. The research questions are: a) to what extent can the students grasp the basic concepts that govern the fire system by interacting with the simulation? b) what are the learning benefits of using the NetLogo tool in the classroom? and c) to what extent engaging with NetLogo can spark students' interest in the learning process?

Methods and findings

The research was carried out in a private school with a sample of N = 22 4th grade students (age 10-11 years old). The teaching intervention had a duration of four teaching hours and is based on the guided inquiry methodology [4]. Students worked in groups to fill out a worksheet while interacting with the model. They had to formulate hypotheses, test them by changing the

[1] http://ccl.northwestern.edu/netlogo/models/Fire
[2] http://ccl.northwestern.edu/netlogo/models/FireSimpleExtension3
[3] http://modelingcommons.org/browse/one_model/7155
[4] http://modelingcommons.org/browse/one_model/7373

parameters in the simulation and reach to the corresponding conclusions with the help of the teacher. Regarding the evaluation of the learning outcomes, students are asked to answer a questionnaire before and after our teaching intervention (Pre-test and Post-test). The questionnaire included open and closed-end questions.

The results that we obtained from the student questionnaires are presented here, based on the most important questions. In the first question “What do you think are the factors that affect the spread of a forest fire?” we noticed that in the Post-tests the answers are more specific and refer more to wind, density, low humidity and fire outbreaks. In fact, the humidity was not there at all in response to the pre-tests.

The next question was "How do you think climate change might affect the spreading pattern of forest fires in the coming years?". In the pre-test, 8 out of 22 students answered that climate change will cause extreme temperatures and heatwaves with the consequence that fires will spread more quickly and easily. While, in the post-test, 14 out of 22 students had the same answer and 3 students reported that there will be low humidity rates due to climate change and fires will spread at a faster rate.

We continue with the question "Can we predict the course and spread of a forest fire?". In the Pre-test, 16 out of 22 students answered "Yes", 5 students "No" and one student "I don't know". In the Post-test, 12 students answered "Yes" and 10 students answered "No". Probably, a different wording of the question would have given us better results as in the worksheets most groups of students wrote that fire does not spread in the same way every time.

The rest of the questions were related to how the spread of a fire is affected by the number and location of the fires, the wind and the humidity of the forest. In the Post-tests we had more complete answers than in the pre-tests especially regarding the humidity of the forest. Also, it would be good to mention the enthusiasm expressed by the students while engaging with the model. In a related question of the questionnaire, 19 out of 22 students answered that they are very interested in interacting again with the NetLogo environment.

Conclusion

Despite the limitations on this research such as the small sample size or the limited teaching time, it appears that the modelling environment of NetLogo can be a valuable tool for the educational community. Regarding the teaching of the basic concepts that govern the fire system, it appeared that students mainly found the unpredictability and non-repeatability of fire, although further research is needed to confirm the above results. The learning benefits vary since the students managed to distinguish the possible factors and the way they can affect the spread of a fire in the coming years. Furthermore, they discovered the effect that climate change can have to the spreading pattern of forest fires. Finally, it is worth emphasizing that despite the young age of the children, they managed to easily use the NetLogo app while their interest and engagement remained undiminished throughout the teaching intervention.

References

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