Observing the Impact of Science Education on Undesirable Behaviors of Students in the Agent-based Simulation Environment

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Abstract: Agent-based modeling is a new computational model for social sciences. Computational models are formulated as computer programs which represent the processes that exist in the social world. When simulations of these computational models for social sciences are performed, it is possible to gather information about real systems' processes and predict future outcomes of the processes. The agent-based model includes a set of agents that represent real actors in a real system in the simulated environment. The simulated environment represents the environment in which the agents contain their resources and perform their actions. Agents interact with other agents and entities in the environment while they try to achieve their individual goals. In the present study, it is aimed to imitate the school environment in a simulation environment by using the Repast Simphony 2.4 simulation tool and observe the impact of science education on undesirable behaviors of students represented by agents in the simulation environment.

Keywords: Education, Agents, Simulation

Introduction

Agent-based modeling is a computational method, which has become increasingly popular to model complex systems in a wide range of applications, such as in the social sciences (Conte & Paolucci, 2014; Epstein, 2007; Klein, Marx & Flschbach, 2018; Tesfatsion & Judd, 2006); since a modeler can build models where individual entities and their interactions are directly represented. In this method, developed models are created as computer programs which are having inputs and outputs that can be considered as independent variables and dependent variables, respectively. These programs represent the processes considered to occur in the real social world. For example, in a school, it is possible to examine students' interactions with each other and their teachers in a simulation environment where the teacher and students are programmed as agents.

The agent-based model is a model in which agents are used to understand the social world. The social phenomenon that will be modeled in an agent-based modeling should be clearly represented in the computer program. In this modeling method, it is possible to define models directly in the form of autonomous individuals, i.e., agents and their interactions (Macal and North, 2009). It is seen that the rule-based individual behaviors of the agents at the micro level and the interaction between agents are likely to reveal the behavior of a social community at the macro level. Therefore, agent-based modeling is often used to capture the complexity of individuals in dynamic settings. It is also possible that the results of the tests carried out on an agent-based model of a social phenomenon are similar to the behavior of the real systems if the model is a successful model. Sometimes it is possible that the results do not reflect the real social phenomenon of the model. In this case, the behavior of the model can be observed by running the tests on the agent-based model with different inputs.

Although, agent-based modeling and simulation is adopted to use in many social science applications, this method has not been applied much in education research. In this study, the role of agent-based modeling and simulation in education is explained through the peer victimization model for education researchers. Thus we aim to describe possibilities of observing undesirable behaviors, such as school bullying in a virtual school environment by using an agent based modeling and simulation. Bullying is defined as a phenomenon that occurs as undesirable behaviors and repetitive negative actions among school aged children. Bullying involves dynamic and negative interactions that are focused on hurting, making threats, harming peers from a group on purpose (Bilgili, Kocaoğlu & Akın, 2016; Gökkaya, 2016). Our model developed will be used to provide a better understanding of the dynamics of school bullying and create a social training environment to educate young teachers without handling unruly students. Thus the teacher may face some sorts of situations and problems in a virtual classroom populated with student agents as if he/she is in a real classroom.

In this paper, we present our model for peer victimization in schools in detail. The principal way in the model we propose is relatively simple: we identify simple rules for interactions between students. Our purpose in this regard is to offer a system that is as simple as possible through a bottom-up modeling approach. The remaining sections of this paper are organized as follows. The section titled "Undesirable Behaviors and Bullying" provides background information detailing the undesirable behaviors in classrooms. The section titled "Method: Agent-Based Modeling and Simulation" presents a brief explanation of the fundamentals of agent-based modeling and simulation. The section titled "Agent-Based Modeling and Simulation of the Peer Victimization" introduces the agent-based peer victimization model. The section titled "Experimental Study" illustrates the experimental model developed for the study, presents the data, our analysis, and a discussion of the approach we used. The conclusion section presents a summary of this research study.

Undesirable Behaviors and Bullying

Student behavior that interferes with classroom management, such as disrupting education and training in the classroom, distracting the attention of all students and disturbing the peace of the class, sometimes bringing about permanent discipline problems, and spreading among other students is called undesirable student behavior.

According to the Cengin Ünüvar (2014) research findings, the behavior problems seen in primary school are:

- Drawing interest conducted misbehavior: Unnecessary speech, complaint, speaking without permission, moving around, dealing with other things, psychological violence, inappropriate expression of emotion, making inappropriate statements.
- Problem behaviors to avoid rules: Not to bring the lesson equipment, to remain unresponsive, to delay the lesson, to litter, to escape from group activities, spitting, copying in the exam
- Problem behaviors due to expression of anger: Suddenly come out of class, stop talking to the teacher, physical violence.
- Problem behaviors due to physiological development problem: Eating under the desk, peeing on pants in the classroom.
- Problem behaviors due to the lack of love and interest: Taking someone's belongings without his/her permission, theft.

Undesirable behaviors such as complaints, psychological violence, improper expression of emotion, improper discourse, spitting, physiological violence, theft, unauthorized taking of friends' belongings are called bullying if these behaviors are repeated to the same students.

Pişkin (2002) examined the definition of bullying and he defined "bullying" as a sort of aggressiveness in which one student intentionally and continuously disturbs the students who are weaker than themselves, and the victims are unable to protect themselves.

According to Pişkin (2002) school bullying can be physical, such as kicking, slapping, pushing, pulling, teasing; it can be verbal, such as mocking, teasing, annoying naughty noun, humiliating words; and it can be indirect, such as spreading the gossip and rumor, leaving the victim out of the group of friends and leaving him/her to loneliness; it can also emerge as behavioral, such as taking money and possessions, threatening to take money and possessions, damage to belongings.

In order to define an action as bullying, it is necessary to have four basic criteria (Gökler, 2009):

- Intentionally harmful
- It occurs repetitively.
- There is a physical or psychological power imbalance between the bully and the victim.
- The victim feels himself/herself helpless and is unable to defend himself against bullies.

Bullies often lack problem solving skills and tend to externalize their own problems. Generally, bullies' school successes are low. The victims take on the most difficult role in the bullying process. One of the most fundamental characteristics of the victims is that they are more anxious and unsafe than other students (Gökler, 2009). They are generally cautious, sensitive and silent. When they are attacked by other students, they usually respond in the form of crying and withdrawal, especially in small class levels (Yıldırım, 2012).

Bullying is resistant to time and negative effects may occur especially in adulthood. Children who exhibit aggression against their peers in their childhood are also more likely to exhibit behaviors such as domestic violence, crime and substance use in the later years. Children who are exposed to chronic bullying, they may experience physical problems, psychological stress, concentration difficulties and school phobia in short term. In the long term, they may not develop and maintain a healthy relationship with the opposite sex and may experience high levels of depression and develop a highly negative self-concept according to their peers who are not subjected to bullying (Gökler, 2009).

If individuals are physically, mentally and socially healthy in a society, then that society is healthy. It is necessary to direct the bullies and their victims, who carry a risk for the society, to science and make use of the rehabilitative effect of science. Because dealing with science is to find the source of the problems, to see the parts as a whole, and to be curious. Science allows us not to escape from problems by being patient and committed and it allows us to dream, to be creative. To deal with science gives an interdisciplinary approach to a person causes an individual to look at events in a multi-faceted way. These children can be given the opportunity to learn computer programming language and make their own computers.

Programming has a close relationship with mathematics, science and technology design. With this method, students can visualize real life problems in computer environment and seek solutions to problems, thus learn to think using algorithmic and logic, understand the common language between machine and human and use what they learn in solving real-life problems. Their computer skills improve. They learn to think abstract, develop their creativity, and become a self-confident individual.

Method: Agent-based Modeling and Simulation

An agent-based model and simulation consists of agents, simulated environment, and simulation environment. The actors of the real system are defined as agents in an agent-based model. Based on the definition of agents made by different researchers, an agent is a software system that acts with a certain degree of autonomy, perceives the changes in its environment and re-evaluates its knowledge according to its perceptions, plans, and interacts with other agents and its environment. This definition determines the features that should be present in the agents and it concerns the people who develop the agent development platforms in computer science. However, these features are not very useful when designing an agent in agent-based modeling and simulation. When defining agents, it is possible to make it easier to design agents using perception, performance, memory, and policy features. Agents perceive the environment in which they are located, that is, the presence of passive objects and agents located in their neighborhoods, and they move around in their environment, communicate with other agents and interact with their environment. Agents can record perceptions of previous states and actions. They have a set of rules, intuitions, or strategies that determine what behaviors they will perform, taking into account their current situation and background (Badham et al., 2018).

The agents are model components that are affected from and influence the simulated environment and the simulation environment. The agents perform their actions in the simulated environment. As a result of the actions of agents, other agents in the simulated environment may also be affected. The simulated environment is composed of active and passive components that cannot be represented as agents, and these components and agents represent the real environment when creating the simulated environment. For example, the simulated environment may represent a geographic area, for example a city and its characteristics, or countries and nations depending on international relations.

The simulated environment also forms the communication channel between agents. Directing all communication between agents through the environment not only corresponds to the natural way, but also to the role of the environment in human relations, but also makes it easier to track the agents.

The simulation environment presents the simulation infrastructure for operating the simulated environment model including the agents. The simulation environment is part of the simulation model that it gives services such as messaging, runtime information, running the simulation and keeping results. The interactions between the agents and the simulated environment during the simulation can produce undefined behaviors in the simulated environment over time. This is called emergence.

Most of the time, simulations use time steps as the concept of time. Each time step is set as the same simulation time. In a simulation step, each agent in the model exhibits it behavior by conducting an action, interacting with other agents or interacting with other components in the environment. In the next section, we explain our agent-based peer victimization model in detail.

Agent-based Modeling and Simulation of the Peer Victimization

We will be building a simple agent-based model involving bullies chasing students (victims) and students running away from bullies. The agent-based modeling and simulation of the peer victimization has three main components: agents, a simulated environment, and a simulation environment. This study has limited parameters such as agents' types, agents' attributes. The bullies and students are the agents of the model. They have attributes and rules and they respond to changes in the environment. The aggressions energy, which is an attribute of the bully and student, defines the extent of the aggressiveness. Whereas bullies engage in physical or verbal bullying to some students, those students become victims. Victims may not fight bullies; they mostly prefer to stay unresponsive. These influence interactions among agents of the model and between agents of the model and the simulated environment.

The simulated environment in the model consists of a grid with 50× 50 grid cells to represent the school environment. Each grid cell provides a suitable environmental layer for bullies to intentionally cause harm to victims. In this study, we used Repast Simphony 2.4 to create agents that are written using Java programming language. After we identify the agents in the simulated environment, it is necessary to explain the behaviors of the agents.

Bully Behavior

At the initialization, the programmer sets the number of bullies to create for the simulation. The bullies are created and randomly assigned aggression energies of between 15 and 30. Each bully is randomly distributed on the virtual school environment (simulation environment) represented by a grid with 50 × 50 grid cells. The bullies' behavior is to wander around looking for victims to attack physically or verbally. Each time step of simulation, each bully will determine where the most students are within its neighborhood and move there. When a bully has discovered the location with the most students that bully wants to move towards that location. All the students at the bully's grid location are obtained and a student is chosen at random from these students. The bully attempts to harm the student at that location and consequently, that student will become a victim. The attacking behavior is repeated, or has the potential to be repeated, over time to the same victims or other new victims.

When a bully attacks a student, the bully takes a task for a certain period of time. As he/she continues to take the tasks, his/her aggression energy decreases. When the bully's aggression energy decreases under a certain value, he/she stops bullying.

Student Behavior (Including Victims and Bystanders)

At the initialization, the programmer defines the number of students to create for the simulation. Students are created and randomly assigned the aggression energies between 4 to 10. Students are randomly distributed in the grid. The basic behavior for a student is to move around randomly and react when a bully comes within its local neighborhood by running away from the area with the most bullies. His aggression energy increases in the attack of the students who act undesirable behaviors (i.e., bullies).

Experimental Study

We performed three experiments in order to observe the impact of science education on undesirable behaviors of students in the agent-based simulation environment. First, we run our simulation when the number of bullies is less than the number of students. Then, the number of bullies is equal to the number of students. Lastly, we run the simulation when the number of bullies is larger than the number of students.

Experiment 1: The number of bullies is less than the number of students

In this experiment, simulation runs with the students exhibiting undesirable behaviors, such as bullying around the students with good behaviors. The behaviors of all students are defined by aggression energy. At the initial time step, a settlement of bullies accrued that ranged in terms of aggression energy from 15 to 30 in the simulation environment. Also, students of acting good behaviors accrued that ranged in terms of aggression energy from 4 to 10. The aim is to distract the bullies by giving them a science task. As illustrated in Figure 1, bullies are represented as red, students exhibiting good behaviors are represented as blue.
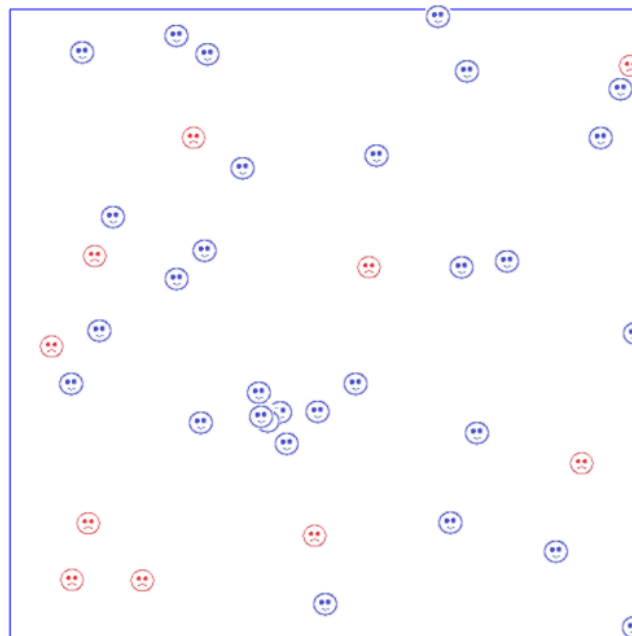

Figure 1. Students and bullies randomly distributed in the simulation environment

The aggression energies of 10 bullies and 200 students are shown in Figure 2. Until the 210th tick count (time step), the mean of aggression energies of bullies decrease whereas the mean of aggression energies of students increase, as we expected. Because students will have an increase in aggression energy as long as they are attacked. When the bullies take science projects, their aggression energies decrease and reach at energy levels such that they never involve dynamic interactions between the victims. After the 210th time step, the mean of aggression energies of bullies and students reach constant values.
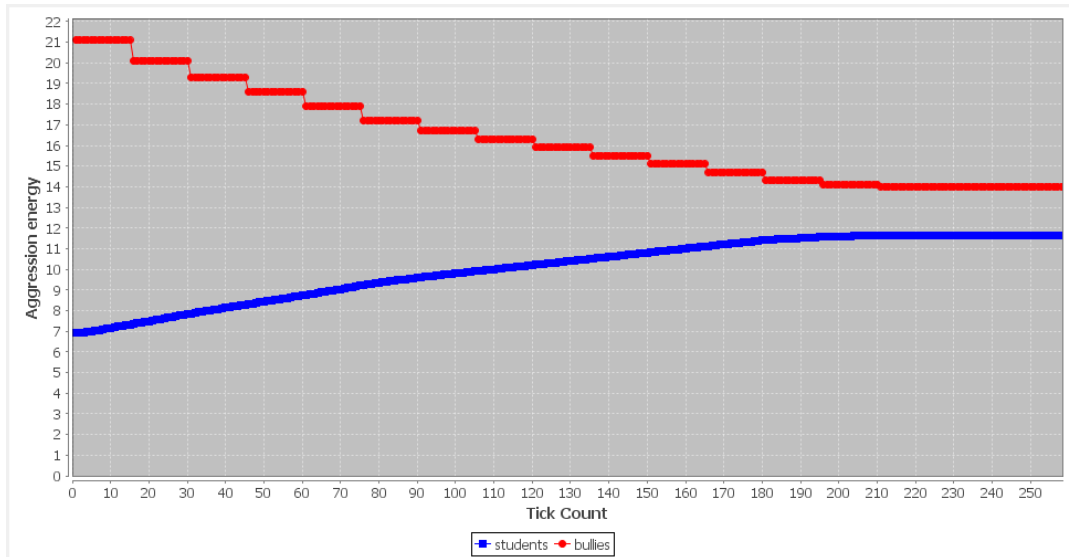
Figure 2. The aggression energy if the number of bullies is less than the number of students

Experiment 2: The numbers of bullies is equal to the numbers of student

In order to study the impact of bullying on the obedient students and the impact of giving science tasks to the bullies, a similar experimental setup as described in experiment 1 was performed. Thus 200 bullies with aggression energies ranging from 15 to 30 and 200 students with aggression energies ranging from 4 to 10 were created in the simulation environment.

When a student is attacked, his/her aggression energy increases in the attack of the students who act undesirable behavior. Therefore, we observed the increase in the mean of aggression energies of students, as seen in Figure 3. At the 32nd tick count, the mean of aggression energies of student reaches the mean of total aggression energies of bullies and it continues to rise. After the 225th tick count, the mean of the aggression energies of bullies and the mean of aggression energies of students reach minimum and maximum values, respectively, and they remain constant at those values.
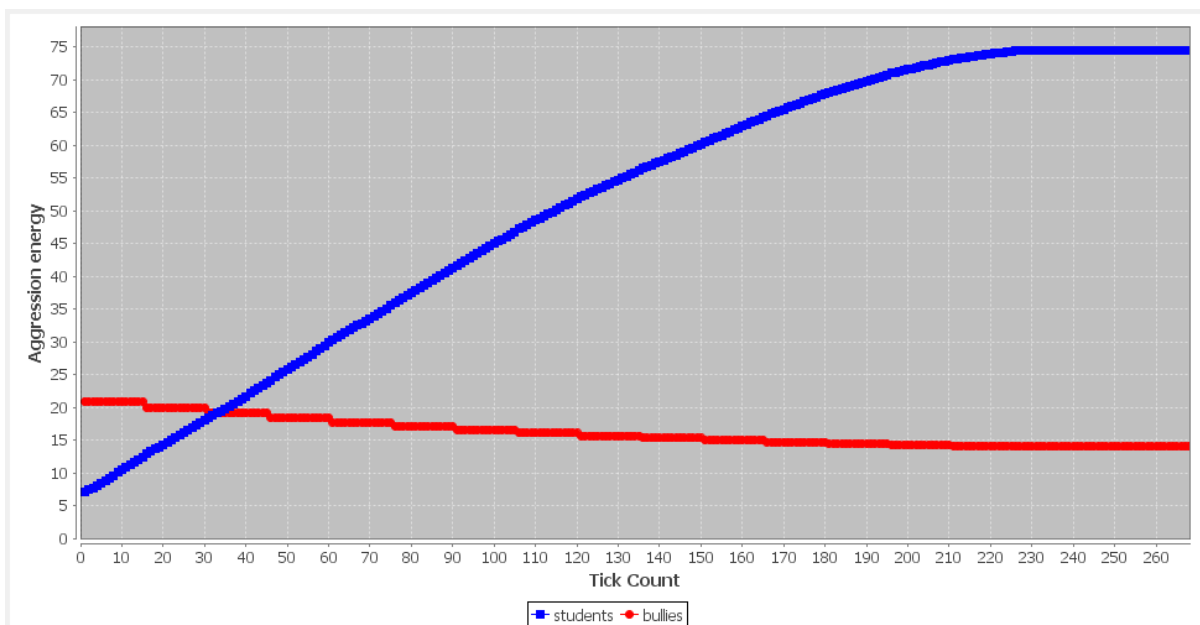

Figure 3. The aggression energy if the number of bullies is equal to the numbers of student

Experiment 3: the number of bullies is larger than the number of students

In order to observe the effect of bullying on the obedient students and the impact of science projects on the bully students, a similar experimental setup as described in experiment 1 and experiment 2 was performed. Thus 200 bullies and 10 students with aggression energies ranging from 4 to 10 were created in the simulation environment.

The graph in Figure 4 shows the mean of aggression energies of the students and the mean of aggression energies of bullies. We observed the increase in the mean of aggression energies of students, whereas we observed the decrease in the mean of aggression energies of bullies, as seen in Figure 4. In this experiment, the number of bullies is very high; therefore, it causes the victims to increase in the number as well. Compared to the experiment 2, the mean of aggression energies of the students reaches the mean of aggression energies of the bullies at the 18th tick count and it continues to rise until the mean of aggression energies of bullies decreases under 15 and remains constant.
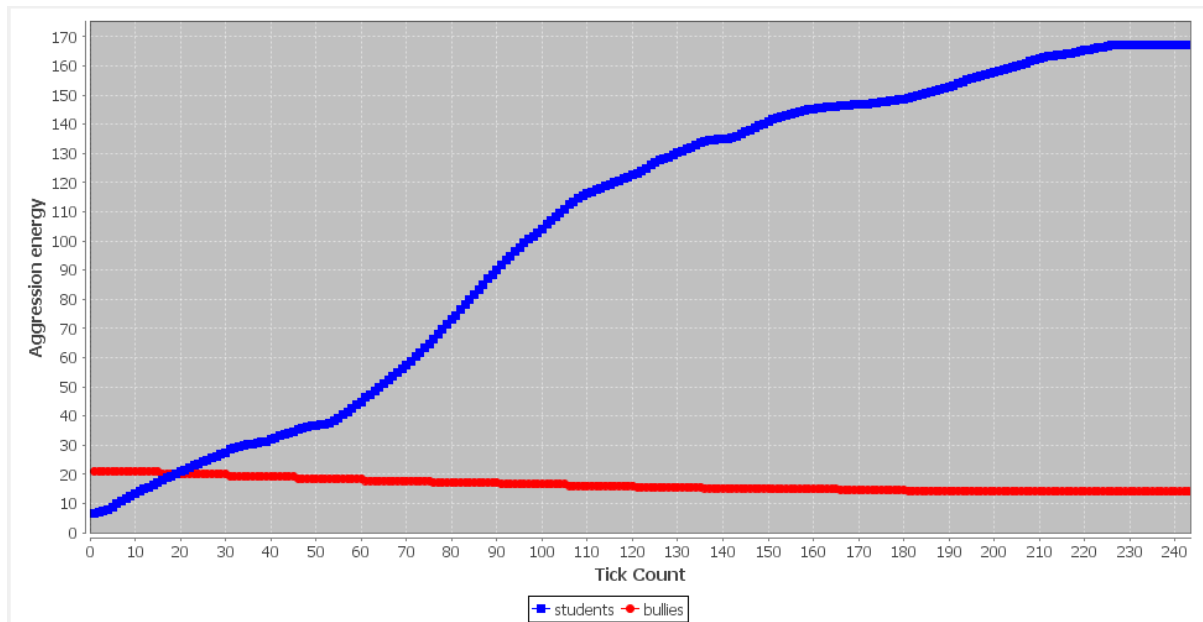

Figure 4. The aggression energy if the number of bullies is larger than the number of students

Conclusion

Agent-based modelling and simulation is a computational method for studying complex systems that it has been used with success in many social sciences. However, this method has not been used much in the field of education. In the present paper, we explained the agent-based modelling and simulation method through modeling of an undesirable behavior involving physical and psychological violence in school environment and we proposed to observe the impact of science education on undesirable behaviors of students by using this model. We presented challenges for applying Agent-based modelling and simulation in the field of education since this study is an interdisciplinary study, thus some difficulties can arise in creation of a system's engineering scenario. Moreover, we discussed some of the potential benefits, such as providing a virtual school environment where a young teacher could train for handling students with undesirable behaviors by playing the role of a teacher.

In our model, we observed bullying acts as an undesirable behavior faced in our virtual school environment. The aggression energies of bullies would decline when they achieved their science projects in the model. Our model is not currently being developed to monitor all undesirable behaviors in the school environment. With the improvement of the model, it will be ensured that a virtual environment will be realized to monitor the activities that disrupt the discipline of the virtual school environment. Thus by using this model, the teacher could explore some sorts of situations and dilemmas that she/he might encounter in the real world.

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