# The Netlogo-based Dynamic Model for the Teaching

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***Abstract*—This paper is to understand the dynamics of teaching behaviors based on complex adaptive system theory and methods of modeling. Due to the complexity and indetermination of complex systems, it is difficult to study the complex systems with the traditional reductive theory. The agent-based computer simulation is approved in the paper. Because classical interactions only among pre-set behavioral models may limit the capability to explore all possible evolution patterns, to tackle this issue, we introduce participating method to the MAS model, propose participator MAS(P-MAS)modeling method. In order to support this new approach, we introduce the concept and framework of artificial classroom (AC) for the first time by employing artificial societies. By adopting the bottom-up modeling technique and MAS model, the innovative dynamic model of AC is built. We have given a system structure of AC, design and implement an AC based on TCP/IP. The AC is currently being developed in NetLogo/HubNet. It provides a good tool to study classroom behaviors.**

***Keywords-teaching model; artificial classroom; multi-agent system; participator modeling method; Netlogo;Hubnet***

## I. INTRODUCTION

The paper focuses on the research of teaching process dynamics, the crucial scientific problem. The activity of teaching is a complex dynamic process. Teachers worry at classroom misbehaviors. Classroom misbehaviors will cause the different changes of classroom discipline which have their important and complex properties. It is impossible to solve this problem with traditional simulation.

By studying the properties of autonomous entities and interactions among them, we attempt to establish a new platform-based teaching process model. Our goals are to get a deeper understanding of complex behavior working mechanism of teaching process dynamics. This project is established on the cross research including information science, system science, education science, etc. It refers to many problems in the field of artificial intelligence, classroom management, and complex system and so on.

This paper is to understand the dynamics of teaching behaviors based on complex adaptive system theory and methods of modeling. The model based on multi-agent has been put forward to research education reform. Combining with the problems of lack of intelligent in the traditional model and it's hard to establish the episodic and some other problems. We propound the idea of bring the agent technology into the teaching model.

Classical interactions only among pre-set behavioral models may limit the capability to explore all possible evolution patterns. To tackle this issue, we regard as each student who share in the process of teaching as an agent, introduce participating method to the MAS model, and propose a participator teaching method. It can make the learners join in the simulation process. Each learner could control a simulation agent, and they could finish the experiment based on the teaching targets.

In order to support this new approach, we introduce the concept and framework of artificial classroom (AC) for the first time. By adopting the bottom-up modeling technique and MAS model, the innovative dynamic model of AC is built. We have given a system structure of AC, design and implement an AC based on TCP/IP.

The AC is currently being developed in NetLogo/HubNet. It provides a good tool to study classroom behaviors. Using the simulation platform HubNet of Netlogo we can set up an education-situation.

## II. AN ARTIFICIAL SOCIETY AND ARTIFICIAL CLASSROOM

### A. *An Artificial Society Model*

Artificial societies are agent-based models of social processes. The artificial society model introduced by [1-4] will be briefly presented, as it will be used for the experiments reported in this paper. Epstein and Axtell applied agent-based computer modeling techniques to the study of the human social and economic phenomena such as trade, migration, regional and cultural group formation, combat, interaction with an environment, transmission of culture, propagation of disease, and population dynamics. In this approach fundamental social structures and group behaviours emerge from individuals operating in artificial environments. Both agents and the environment have simple local evolution laws, thus requiring only bounded demands on each agent's information and computational capacity. Each agent has internal states and behavioral rules that can change through interaction with other agents or with the environment. The agents are the people of the artificial society. Each agent is characterized by a set of fixed and variable states. At a certain moment, the agent is located in one site of the environment.

For this research an agent is defined as a computing entity which performs some information processing to achieve specific task [5, 6]. According to [7], an agent can also be defined as:

A software-based computer system that enjoys the following properties:

- Autonomy: agents operate without the direct intervention of humans or others, and have some kind of control over their actions and internal state;

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- Social ability: agents interact with other agents (and possibly humans) via some kind of agent-communication language;
- Reactivity: agents perceive their environment, (which may be the physical world, a user via a graphical user interface, a collection of other agents, the INTERNET, or perhaps all of these combined), and respond in a timely fashion to changes that occur in it;
- Pro-activeness: agents do not simply act in response to their environment; they are able to exhibit goal-directed behavior by taking the initiative.

An agent has believable properties that represent human being characters (personality). These include properties like knowledge, belief, intention, desire, and so on. An agent also has a mobility property, it can move from one machine to another across a network. An agent works to achieve its goals without interfering against other agents goals. In addition, it does not transmit false information to other agents and the environment it lives in. For a program to be an agent there must exist an environment. The agent lives in the environment and has some knowledge and belief of the environment [5, 7].

An agent is part of the environment it lives in and senses the environment. It has a goal and uses its sense knowledge to achieve its goal. It takes action for its input, and uses and interprets the output autonomously by acting upon the environment. It has specific goals and the output of the action it takes can effect the future sensing of the environment. In other words, an agent can change its behavior due to the action and interaction among other agents and with the environment. The agent then senses the environment with its new behaviours. An agent also acts continuously over a specific time stamp [5,6,7].

A multi-agent system consists of components (entities) that represent the features of the system. The entities communicate with each other and with the environment they live in, and are modeled and implemented using agents[8]. The agents have behaviours and characteristics and they represent the various components that make up the model. They have also some communication protocol which helps them understand messages and exchange information among each other. The model is the outcome of the characteristics and behaviours of the agents and their interaction among each other and with the environment they live in [8]. The characteristics and behaviours of agents in a multi-agent system can be viewed from two aspects: the internal and external. The internal aspect corresponds to the agents' internal characteristics and behaviours whereas the external aspect consists of the agents' behaviours and characteristics when interacting with other agents and the environment they live in. Modeling a complex system with multi-agent system considers both these aspects of the agent [8].

The aim of the research is to grow artificial societies that can be used as laboratories for social sciences and in the same time to discover the fundamental local mechanisms and proprieties that are enough to generate a collective behavior of a certain complexity.

### B. *Artificial Classroom*

The simplest experiments on the artificial society describe above implies the survival of a population of agents in a certain fixed environment.

Classroom is a complex social system constituted by teacher, students, and environment, in which teacher and students complete the teaching program through mutual influence and then achieve the teaching goal. Classroom management is the basic condition for the teaching program survival and an important guarantee for the smooth complement of the class program.

The basic idea of the artificial classrooms is to use artificial society theories, methods and MAS modeling technology so as to raise classroom behavior problems. By artificial classrooms, we can test on the specific issue of classroom behaviors, and repeat the test, then conduct a comprehensive, accurate and timely assessment and amendment to a specific teaching programme. Meanwhile, by combining artificial classrooms and practical teaching system, we can not only improve and optimize teaching management and control system, but also virtually train administrators and teachers in the teaching system to enhance learning efficiency and the reliability of operation.

Emergence plays the key role in the analysis of artificial classrooms, in essence, it is a method that tests, observes and describes. Through the method, artificial classroom can raise conveniently various classrooms problem behaviors. Through designing different test schemes and remaking tests by artificial classrooms, we can analyze and evaluate various teaching schemes [9].

It is usually impossible to be analyzed and evaluated because of the lack of enough data in realistic educational system, but this can be completed conveniently in artificial classrooms. Especially, artificial classroom not only simulate realistic classrooms and replace realistic classrooms. It has also enlarged the reliability of its result and the suitable scope of quantification analysis.

Besides, in artificial classrooms, we can repeatedly carry out the experiment for teaching schemes.

## III. THE REALIZATION OF MODEL BASED ON HUBNET

This model can be realized based on the environment of NetLogo. NetLogo is a mature multi-agent modeling platform. It has been developed for over 8 years at Northwestern University's Center for Connected Learning and Computer Based Modeling under the leadership of director Uri Wilensky. NetLogo has an estimated twenty thousand current users. With NetLogo, one can model complex systems with thousands of interacting agents, and study the connection between the micro-level rules and the macro-level "emergent" patterns. Agents can be moving entities or stationary cells as in a cellular automaton and thousands of these agents follow rules in the simulated system, acting in parallel and affecting other agents, both moving and stationary. NetLogo has found use by many natural and social scientists as a research tool and has also been adopted as a successful element of curriculum by hundreds of educational institutions. The emergent phenomena modeled span a wide range of domains including ecosystems, economies, organizational change, and molecular interactions and reactions [10, 11].

NetLogo is a programmable modeling environment. It comes with a large library of existing simulations, both participatory and traditional, that we can use and modify. Content areas include social science and economics, biology and medicine, physics and chemistry, and mathematics and computer science. Students can also use it to build their own simulations.

In traditional NetLogo simulations, the simulation runs according to rules that the simulation author specifies. HubNet is a technology that lets us use NetLogo to run participatory simulations in the classroom. In a participatory simulation, a whole class takes part in enacting the behavior of a system as each student controls a part of the system by using a networked computer.

For example, in the Class misbehavior dynamic simulation, each student controls an agent in a simulated class. A system structure of artificial classroom shows as Fig.1. This system includes:

- The subsystem of teachers and students: This system is formed by teacher and student agents. Each agent has characteristics and behaviors that represent it.
- The subsystem of classroom management: Classroom management is to ensure that classroom teaching goes on smoothly and coordinate the relation between student populations in classroom
- The subsystem of Classroom environment: This is the place that carries out various teaching activities. This agent represents the environment in which the student populations live. The agent has characteristics and behaviors. The properties of the environment agent can change based on the emergence of new changes which is caused by the interaction of the different student populations.
- The subsystem of result analysis: The subsystem produces the result of the expected output. The agent contains the results of all the information obtained from the simulation process.
- The subsystem of teaching goal and task plan: This subsystem is to solve how to set teaching goal and distribute teaching task.

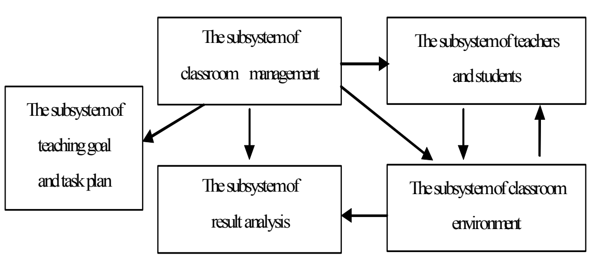


Fig.1 Multi-agent system architecture of AC

As the simulation runs, data is collected which can afterwards be analyzed on a computer.

Based on NetLogo platform, and with the use of the programming language that platform offers, we have preliminarily realized the simulation of classroomdiscipline change. In the model, the entire environment and agent show with 2 dimension grids

Classroom discipline is a complex, changeful and dynamic course, and thus teachers can not foresee the various accidents and students' reaction in. In actual teaching, those often happen. In order to deal with various teaching accidents, it is necessary to design a set of specific and feasible teaching schemes with every teaching link also having many schemes.

## IV. A SYSTEM STRUCTURE BASED ON HUBNET ARCHITECTURE

HubNet adds a new dimension to NetLogo by letting simulations run not just according to rules, but by direct human participation. HubNet simulations are based on a client−server architecture. The activity leader uses the NetLogo application to run a HubNet activity. When NetLogo is running a HubNet activity, we refer to it as a HubNet server. Participants use a client application to log in and interact with the HubNet server.With Computer HubNet, participants run the HubNet Client application on computers connected by a regular computer network.

Fig. 2 and Fig.3 show that students engaged in participatory simulation supported by HubNet network. Each student sees her/his own computer view in Fig.2. Fig.3 is the projected classroom display of the emergent result.

Figure 2. Students engaged in participatory simulation supported by HubNet network. Each student sees her/his own computer view.

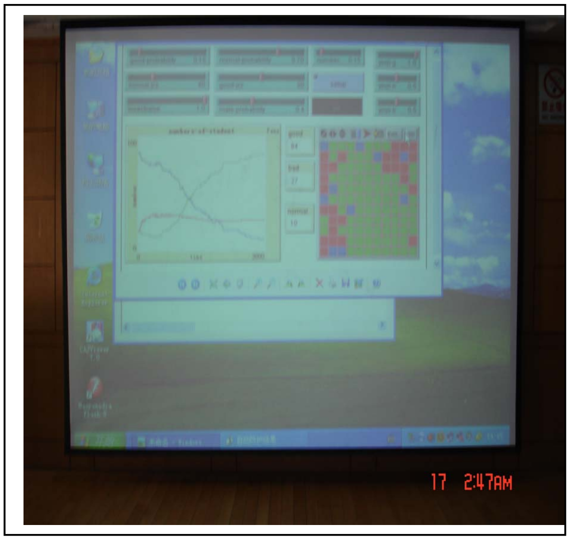


Figure 3. The projected classroom display of the emergent result

## V. A CASE STUDY BASED ON HUBNET

### A. *Model Environment*

Classroom discipline changes (at macro-level) can be represented as complex self-organizing systems that emerge from the interaction of student agents that form a class (at micro-level). Modern multi-agent systems can be employed to explore "artificial societies" by reproducing complicated social behaviors. The class environment in reality has extremely complex social and natural properties, which also has an important influence on how classroom discipline changes .This paper explores organization structure of student population, as well as this kind of individual behavior differences that the structure determine for the change of classroom discipline. For this purpose, the model this research establishes will neglect the leading role of class environment for student individual behavior. Environment is the 2 dimension grids of a X*Y based on the cellular automation.

### B. *Agent*

In fact, classroom activities include the behavior of different levels such as study, discussion and management. But for a simpler model, we abstract all classroom activities to one classroom activity. That is communication.

Agent property is as follows

sex：Student sex is used to control students' choice of communicating objects

Affect ability (infect)：Represent the influencing ability of students who communicate with other students

Self appraisement value：This value determines the discipline condition of students in class.

Agent behavior rules are as follows:

- Communicate: Each agent selects a communicating agent from eight neighboring objects. The sex of the communicating object and the agent determine whether the agent will communicate with the object.
- Affect: If the self value is more than 60, it will have a positive influence on the communicating object and the value of the latter will increase. If the self value is between 30 and 60, it will have a random influence on the communicating object. If the self value is less than 30, it will have a negative influence on the communicating object and therefore reduce the its value.
- Change: Judge self appraisement value according to the scope of appraisement value and then change the color.

### C. *Other Parameters and Variables*

The model includes the following parameters and variables:

- The boundary value of agent grade partition
- The proportion of agents at different levels
- The number of agents interacting in classroom

The model first runs according to initial set state of related parameters, agent number, sex proportion, initial value of agent property and so on. After the initial run, seats and agents' location in classroom will not change. This fully simulates the arrangement condition of student seats in classroom.

Next, we have made an artificial classroom model based on TCP/IP.

## VI. CONCLUSION

Because classical interactions only among pre-set behavioral models may limit the capability to explore all possible evolution patterns, to tackle this issue, we introduce participating method to the MAS model, propose participator MAS(P-MAS)modeling method. In order to support this new approach, we introduce the concept and framework of artificial classroom (AC) for the first time by employing artificial societies. By adopting the bottom-up modeling technique and MAS model, the innovative dynamic model of AC is built. We have given a system structure of AC, design and implement an AC based on TCP/IP. The AC is currently being developed in NetLogo/HubNet. It provides a good tool to study classroom behaviors.

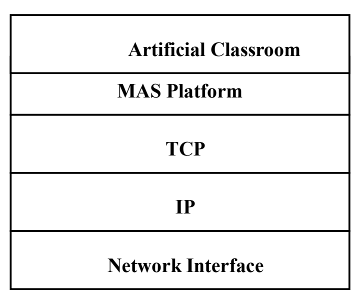


Figure 4. TCP/IP-based AC Architecture

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