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# *Artificial-society-based Classroom Behavior Dynamic Research*

*Wang Lijun*
*School of Information Science & Engineering*
Bohai University
Jinzhou, China
jsma1111@sina.com

*Zhao Chunxiao*
*Department of Computer*
Beijing University of Civil Engineering and Architecture,Beijing, China
zhaochunxiao@sohu.com

***Abstract*—This paper introduces the concept and framework of artificial classroom (AC) for the first time by employing artificial societies. Our solution is to use the artificial society approach for modeling artificial classroom. In the artificial society approach, agent-based simulation is used to explore and understand classroom misbehaviors issues. Student agents are selected as three kinds of typical agents and actions of the agents such as communicating, affecting and changing are all designed in detail. Thus, interactions among various agents and between agents and their environment are realized. Using NetLogo multi-agent platform, simulation programs of the model are developed. The simulation results reproduce the emergent pattern in time space and physical space.**

***Keywords-Artificial Societies; Artificial Classroom; Multi-Agent System; Complex System; Netlogo***

## I. INTRODUCTION

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. This paper aims to present a solution to the above issue. This paper is to understand the dynamics of classroom misbehaviors based on complex adaptive system theory and methods of agent-based modeling. Our solution is to use the artificial society approach [1] for modeling artificial classroom. In the artificial society approach, agent-based simulation is used to explore and understand classroom misbehaviors issues. The approach has been widely used since 1990s among social scientists.

This paper discusses a case study where the artificial society approach is used to model classroom behavior dynamics (CBD) based on artificial classroom (AC).

## II. AN ARTIFICIAL SOCIETY AND ARTIFICIAL CLASSROOM

The paradigm of artificial societies aims to simulate human societies and to study collective (social) phenomena from bottom up. The model of this new paradigm is introduced by Epstein and Axtell (1996) and is called "sugarscape". This model has a very well suited associated architecture: cellular automata. Basically, cellular automata are lattices of cells evolving synchronously according to identical local rules that depend on local conditions. Appropriate combinations of cellular automata successfully sustain artificial society's models and experiments. Artificial societies combine cellular automata and agent-based modeling.

Artificial societies are agent-based models of social processes. An artificial society consists of (1) agents, (2) an environment or space, and (3) rules. 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 [2]. 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 [3, 4]. According to [5], 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;

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

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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 [3, 5].

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 [3,4,5].

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 [6]. 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 [6]. 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 [6].

The aim of the research is to grow artificial societies that can be used as laboratories for pedagogy 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.

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 research is to use artificial society theories, methods and MAS modeling technology so as to grow artificial classrooms. 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 grow conveniently various classrooms problem behaviors. Through designing different test schemes and remaking tests by artificial classrooms, we can analyze and evaluate various teaching schemes [7].

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.

An AC system is a computational laboratory that permits the study of systems of multiple interacting agents by means of controlled and replicable computational experiments. Each partial meaning of AC system is as follows.

The subsystem of teachers and students(TS): This system is formed by teacher and student agents. Each agent has characteristics and behaviors that represent it.

The subsystem of classroom management(CM): Classroom management is to ensure that classroom teaching goes on smoothly and coordinate the relation between student populations in classroom.

The subsystem of result analysis (RA): 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(TA-TP): This subsystem is to solve how to set teaching goal and distribute teaching task.

The subsystem of classroom environment (CE): 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.

A system structure of artificial classroom shows as Fig.1.

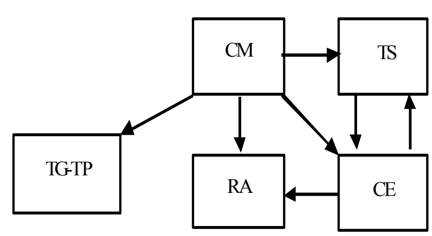


Fig.1 Multi-agent system architecture of AC

## III. AN AC-BASED CASE STUDY: CLASSROOM BEHAVIOR DYNAMICS

### A. *Model Environment*

We have made an artificial classroom model based on TCP/IP(See Fig. 2).

This model can be realized based on the environment of NetLogo[8,9]. 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.

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 behaviours. 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 determines 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 an X*Y based on the cellular automation (See Fig. 3).

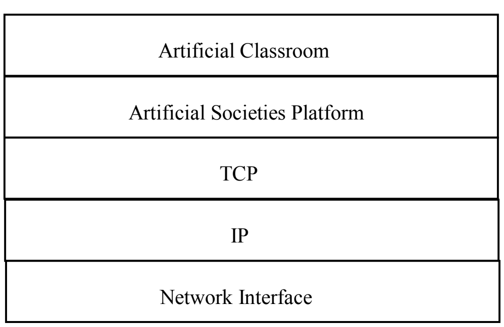


Fig. 2 TCP/IP-based AC Architecture

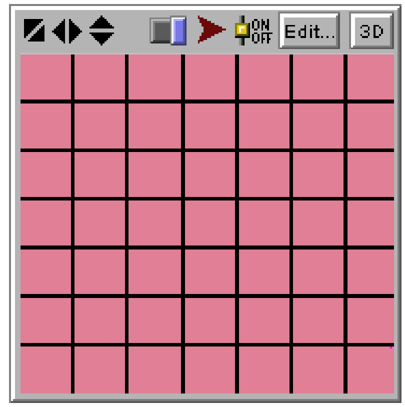


Fig. 3 Environment

### 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 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: (1)The boundary value of agent grade partition; (2)The proportion of agents at different levels; (3)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.

## IV. The Realization of Model and Analysis of Result

Based on NetLogo platform, and with the use of the programming language that platform offers, we have preliminarily realized the simulation of classroom discipline change and have shown it by graph. Fig. 4 shows the dynamics of the student populations in the experiment. The left of the figure shows the emergent pattern in time space and the right of the figure shows the emergent pattern in physical space.

### *A. The Emergent Pattern in Time Space*

In simulation course, we can observe the three-stage dynamics of student populations on time space. The three-stage dynamics include the initial emergent response(before line 1 in Fig 5), the changing emergent pattern (between line 1 and line 2)and the stable emergent pattern(after line 2 in Fig 5).In initial emergent pattern, the number of students changes little, showing that when students begin to attend class, they are in short time behavior pattern. After the initial emergent pattern, in the line 1, the appearance of “inflection point” indicates entering the changing emergent pattern. In this pattern, the number of students changes greatly. In detail, the number of good student’s increases, the number of bad students increases a little and the number of medium students decreases. Usually, the number of good and bad students is less, while the number of medium students is always the most. After a time, some medium students become good students for the influence of good students, while some become bad students for the influence of bad students. Therefore the number of medium students decreases obviously, showing that the number of students has entered polarization state. In the line 2, “inflection point" arises again and indicates entering the stable emergent pattern in which the number of students is in stable state. The polarization state will maintain until the simulation finishes.

It can be concluded that the typical three-stage dynamics of student interactions is well reproduced in the simulation, which means that the time pattern emerges from the interactions among three kinds of students. This conclusion also explains the validity of the model, and shows that complex system theory and its related simulation technology can also be applied to educational problems.

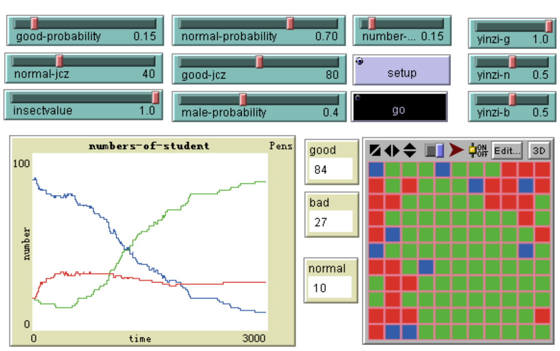


Fig. 4 Simulation interface

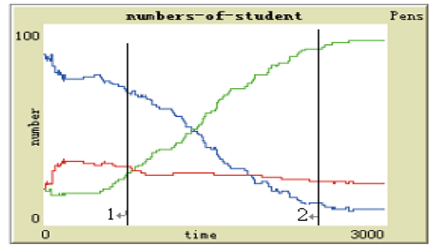


Fig. 5 State change curves

### *B. The Emergent Pattern in Physical Space*

In physical space, the entire environment and agent show with 2 dimension grids. In graph, different colors represent the value of different agents. Red represents that students whose discipline is bad, blue represents students whose discipline is medium and green represents students whose discipline is good. A dynamic graph of the population levels of students can be viewed alongside the graphics screen. Fig.6 shows the dynamics of the student populations in physical space.

The emergent pattern of good student populations in physical space: At the beginning, the number of good students is less, but in the process of simulation, the number was becoming more and more. From the inter-relationship among them, at the beginning, they are decentralized. With the simulation, good students gradually gathered in small groups and physical pattern was becoming more and more obvious. The reason for this phenomenon is that there are interactions among students. As good students in small groups are psychological compatibility, and strong cohesion.

The emergent pattern of bad student populations in physical space: At the beginning, the number of bad students is more, but in the process of simulation, the number was becoming less and less. Similarly, from the inter-relationship among them, at the beginning, they are decentralized. With the simulation, bad students gradually gathered in small groups and physical pattern was becoming more and more obvious. The reason for this phenomenon is that there are interactions among students. As bad students in small groups are infighting, away, on parallel tracks, low cohesion.

|---------Begin---------|-------- Middle--------|---------- End---------|

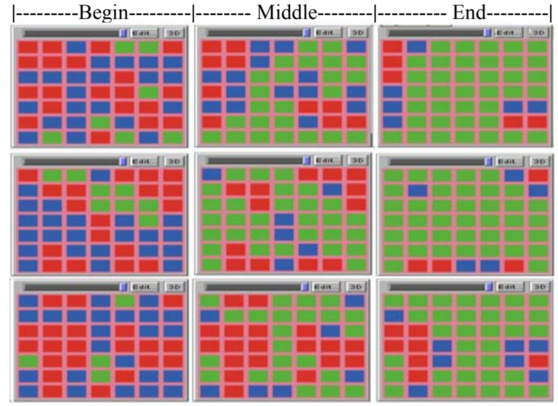

Fig. 6 The dynamics of the student populations in physical space

The emergent pattern of medium student populations in physical space: Students in secondary distribution of the physical entity model: medium student is similar to poor student.

## V. CONCLUSIONS

Our solution is to use the artificial society approach for modeling artificial classroom. In the artificial society approach, agent-based simulation is used to explore and understand classroom misbehaviors issues. Student agents are selected as three kinds of typical agents and actions of the agents such as communicating, affecting and changing are all designed in detail. Thus, interactions among various agents and between agents and their environment are realized. Using NetLogo multi-agent platform, simulation programs of the model are developed. The simulation results reproduce the emergent pattern in time space and physical space.

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