A Multi-Level Complex Adaptive System Approach for Modeling of Schools

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Abstract. The amount of data available to build simulation models of schools is immense, but using these data effectively is difficult. Traditional methods of computer modeling of educational systems often either lack transparency in their implementation, are complex, and often do not natively simulate non-linear systems. In response, we advocate a Complex Adaptive Systems approach towards modeling and data mining. By simulating agent-level attributes rather than system-level attributes, the modeling is inherently transparent, easily adjustable, and facilitates analysis of the system due to the analogous nature of the simulated agents to real-world entities. We explore the design a CAS model of schools using multiple levels of data from varied data streams.

Keywords: Complex Adaptive Systems, Agents, Educational Data Mining

1 Multi-Level CAS Design of an Educational System

As schools become increasingly wired, the ability to collect data at multiple levels has grown exponentially to the point of becoming overwhelming. We classify the multiple data streams into four levels: Individual, Classroom, School, and District. This work is centered on finding the complementary links between these levels and using them together to bring a much clearer picture of the overall educational system.

At the highest levels, most of the academic work in the fields of learning analytics, educational data mining, and intelligent tutoring systems focus specifically at the classroom level or the individual student level using data from learning management systems or finer grain data from logs created from educational technologies[3]. Some work has brought together log data and correlated it with student grades, but little has been done to harness all of these data streams into a robust model. We propose a CAS (Complex Adaptive System) model to do this, for two reasons: the inherent transparency of using agent-based analogues, and the ease with which a CAS model can represent non-linearities.

Educational systems currently collect many characteristic-, performance- and outcome-level data, including grades, test results, economic status, gender, age, race, etc. However, such data, while useful, still leave many aspects of classroom

performance unreported. For example, none of them include the nature and frequency of interactions among students, teachers and students, students and principals, teachers and principals, or principals and superintendents. In addition, there are no correlations between the availability of resources, the nature of such interactions, and the overall performance of students and schools/school districts. Due to the interactive nature of the classroom there is also a great potential for threshold "tipping point" effects to exist, and it is intuitively true that some students or student clusters can have an outsize effect on the rest of the class. One of the goals of this research will be to discover and understand the underlying dynamics of such threshold effects, within the classroom, the school, and the district-wide school system, so that a smarter approach in resource allocation can produce a more effective educational system.

This work identifies the links between multiple streams of data and the development of CAS model to represent an entire school ecosystem, from the individual student to the district level. The end result of this effort will produce a robust model of an educational system at multiple scales, one that can not only help determine the causal factors of desirable outcomes, but also allow for multiple "what if" scenarios to be run in simulation, so that these outcomes can be improved and resources are expended in the most efficient manner.

References

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