Group-Based Cloud Computing for STEM Education

TEXAS Education
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Abstract

The Group-based Cloud Computing (GbCC) for STEM Education Project investigates pre-service teacher designing, developing, implementing, and enacting a socio-technological system for group-centered STEM teaching and learning consistent with a nationally recognized pre-service program. The project takes a design-based research approach to creating and studying technologies and materials that support generative teaching and learning in STEM. Computational thinking, including agent-based modeling, and simulation across STEM domains as well as geo-spatial reasoning about personally meaningful learner-collected data provides an important scientific foundation for the project. This will be achieved by developing a highly-interactive and group-optimized, browser- and cloud-based, device-independent and open-source architecture and by integrating and extending leading computational tools including the NSF-funded NetLogo Web agent-based modeling language and environment.

Framework

Three prior and continuing frameworks are to be integrated in this ITEST project are:

- (1) the NetLogo (Wilensky, 1999) agent-based and aggregate modeling and participatory simulation (HubNet, Wilensky & Stroup, 1999) capabilities,
- (2) the completely open-standards based, group-situated, device independent, and database mediated cloud-in-a-bottle (CiB) network architecture (Remmler & Stroup, 2012) and
- (3) the use of socially-mediated generative activity design for supporting STEM focused learning and teaching in classrooms (c.f. Stroup, 2007, Ares, 2009, Brady, 2014).

Our approach extends to group-level interactivity in classrooms a longstanding commitment in the learning sciences to develop "shared environments that permit sustained exploration by students and teachers" in a manner that mirrors the kinds of problems, opportunities, and tools engaged by experts (LTC, 1992 p. 78).

Research Design

The project takes a design-based research approach to creating and improving the technologies and related project materials. Key to this design effort is a focus on supporting and advancing the ability of pre-service and in-service teachers to pursue participatory and more-fully socially mediated approaches to classroom-based learning. This STEM-specific focus on teaching and learning in classrooms is framed by what we consider a vitally important design consideration: The most consistent and conspicuous feature of school-based learning is that it takes place in a group setting.

Our work is framed by a conjecture that if we can iteratively develop a low-cost, research-based, device independent, user-authorable, highly-interactive architecture that supports authentic group-based STEM learning and teaching in classrooms then we can dramatically increase students on-going development and motivation to participate in STEM-focused coursework and careers.

To help ensure the activities supported by this group-based cloud computing architecture mirrors the kinds of problems, opportunities, and tools engaged by experts we draw upon the Legacy Cycle as situated within a Project Based Instruction framework.

Project-Based Instruction Extended to Group-Based Interactivity

Project Based Instruction (PBI) framework can be used to address the learning design potential of the highly interactive, group-based functionality we are developing. We choose one example from the core set of activities we will release with the GbCC architecture to illustrate the integration with an extended PBI framework. Managing and optimizing traffic flow is an engaging area of research in civil engineering with practical personal implications for many of us, including school-aged students who are, or may soon be, drivers themselves. By providing a highly interactive cloud-based environment for having students in a classroom control individual lights in a simulated traffic grid (cf., Wilensky & Stroup, 2000).

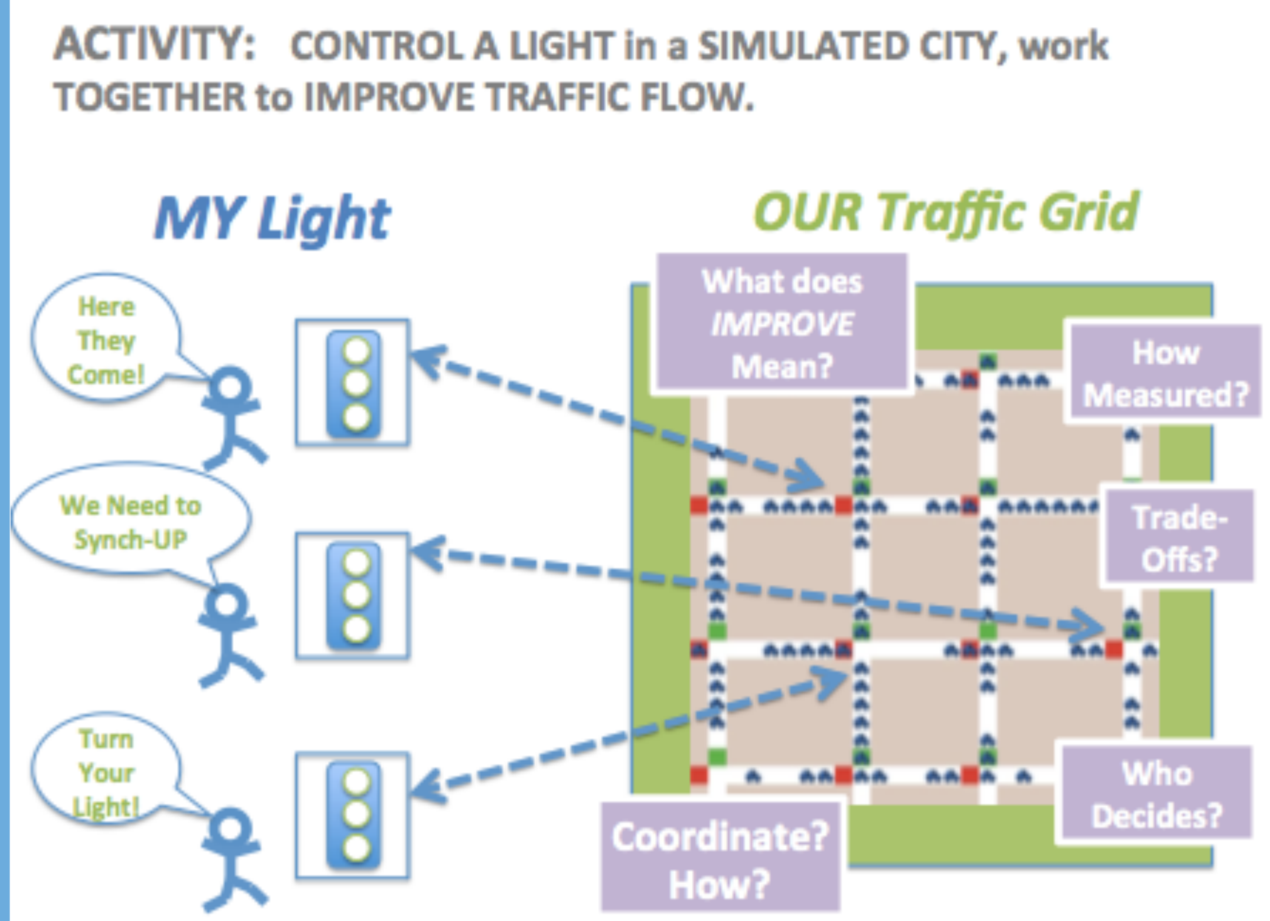

***Figure 1.* Group-Based Traffic Simulation**

The Legacy Cycle uses challenges as anchors for learning. The challenge of improving traffic flow in a simulated city is an example of anchor for classroom-based learning using group-level interactivity. Challenges within the legacy cycle are designed to create an increasing depth of knowledge in a specific subject, with each challenge presented as one cycle of the Legacy shell. The combination of well-designed challenges and meaningful learning activities provides a rich environment for both the students and the instructor.

Learning from a Decade of Implementation Research

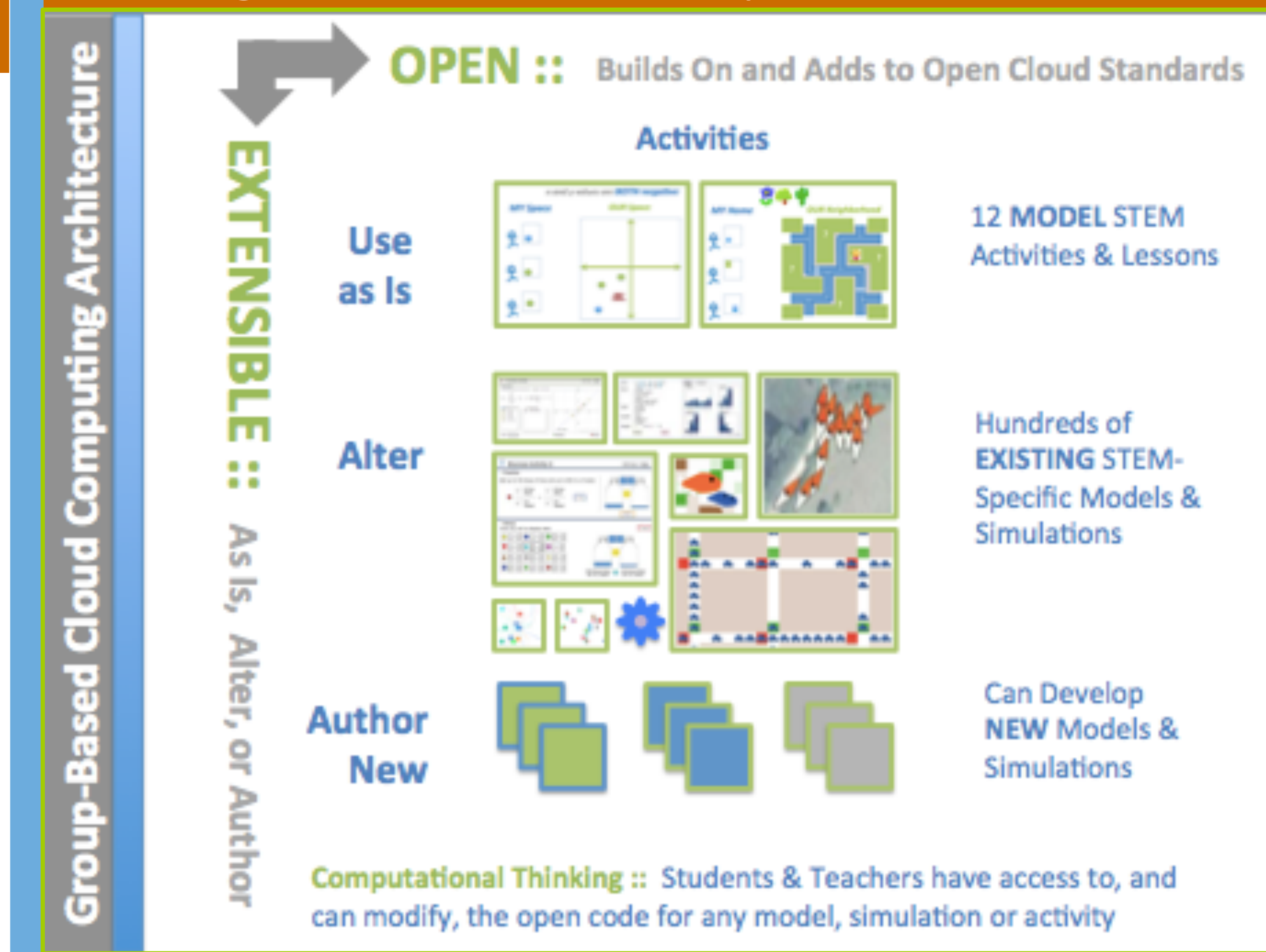

***Figure 3.* Group-Based Cloud Computing Architecture**

STEM-specific technology integration – as this includes agent-based modeling, simulations, the extensive use of digital probes, real-world data analysis and an inclusive approach to computational literacy – has been one of the "cross-cutting" themes of the UTeach STEM program from its inception. Our approach to computational literacy includes the ways in which our building on open standards – e.g., moving from Java-based implementations to HTML5, JavaScript and open-standards for database utilization – supports not just the implementation of existing models and materials, but the extension and full authorability of such capabilities by students and teachers alike.

Similarly, in the UTeach program the pre-service teachers are encourage to develop lessons that fit with their pedagogical vision. Whether by modifying existing models or by authoring their own environments, a key feature of the proposed GbCC architecture is that it would be fully extensible/authorable for students and teachers alike. Computational literacy and agency thereby would be supported as a built-in feature of the next-generation, cloud-based capabilities of the proposed GbCC architecture. We believe this kind of programmability will be important to the on-going needs of the UTeach program and then much more broadly in support of pre-service and in-service STEM educators.

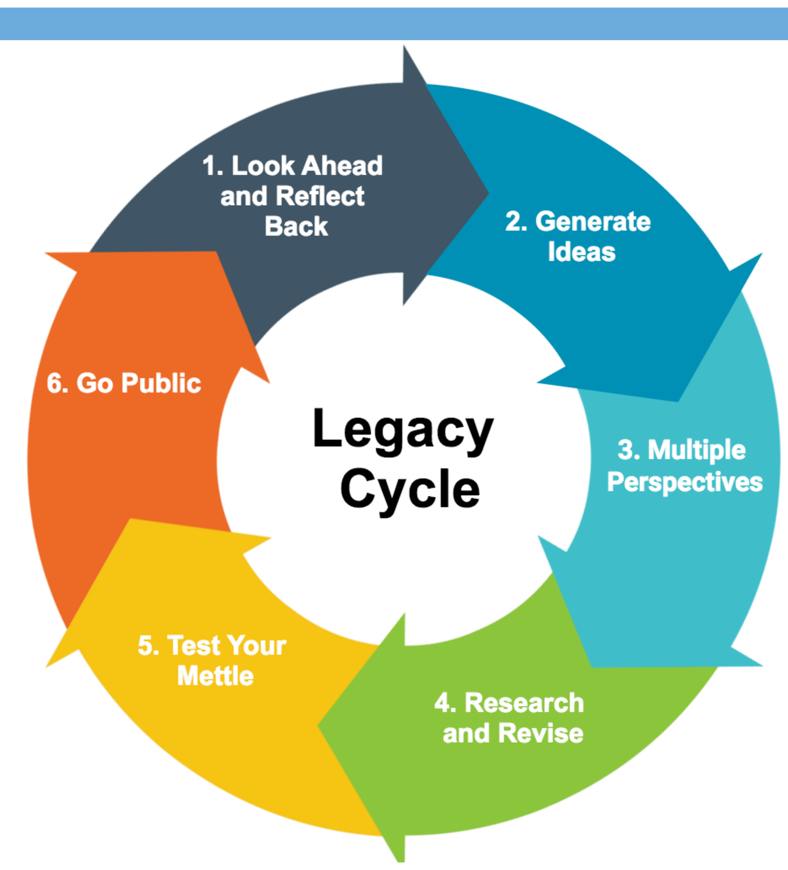

***Figure 2.* The Legacy Cycle**

Phase 1 - Within a traffic simulation, each student controls one light in a simulated city.

Phase 2 – Students generate ideas allowing them to explore, within a group setting, their initial thoughts and conjectures about the challenge at hand.

Phase 3 – Students compare their ideas with multiple perspectives by listening and sharing with others.

Phase 4 – As a group, students research and revise their hypotheses concerning a challenge.

Phase 5 – Formative assessment strategies allow participants to reflect on what they have learned thus far, and to identify any weaknesses or misconceptions about their challenge.

Phase 6 – Learners synthesize what they have learned and either provide a solution to the initial challenge, or to a similar challenge but in a different context, or both.

Commitments to Equity

By leveraging the equity related commitments and the on-going lesson implementation infrastructure of the nationally recognized UTeach STEM pre-service program, a significant number of students in diverse, yet underserved, schools will gain direct access to: (1) next-generation, fully author-able/programmable, group-oriented, STEM-focused, cloud-based computing and (2) participatory approaches to STEM-focused computer modeling and classroom-based inquiry meant to advance the students' abilities in, and sense of on-going personal self-identification with, future participation in STEM-related coursework and careers. Our researching, iteratively developing, and implementing -- across many schools, subject-areas, and grade levels -- a scale-able and low-cost technological and pedagogical infrastructure is intended to directly address both the near term and longer term goals of the ITEST Program regarding students' future participation in the STEM workforce.

A broadened version of the core conjecture of the project that was introduced earlier is that by valuing and improving STEM-focused participation in classrooms we will directly support all students' sense of the value and importance of participation in STEM educational pathways and STEM careers. Increasing the connections between the students' sense of who they are and the highly interactive forms of STEM-related learning and teaching to be advanced by this project stand to improve the diverse, but underserved, students' ongoing personal identification with STEM-related educational pathways and careers.

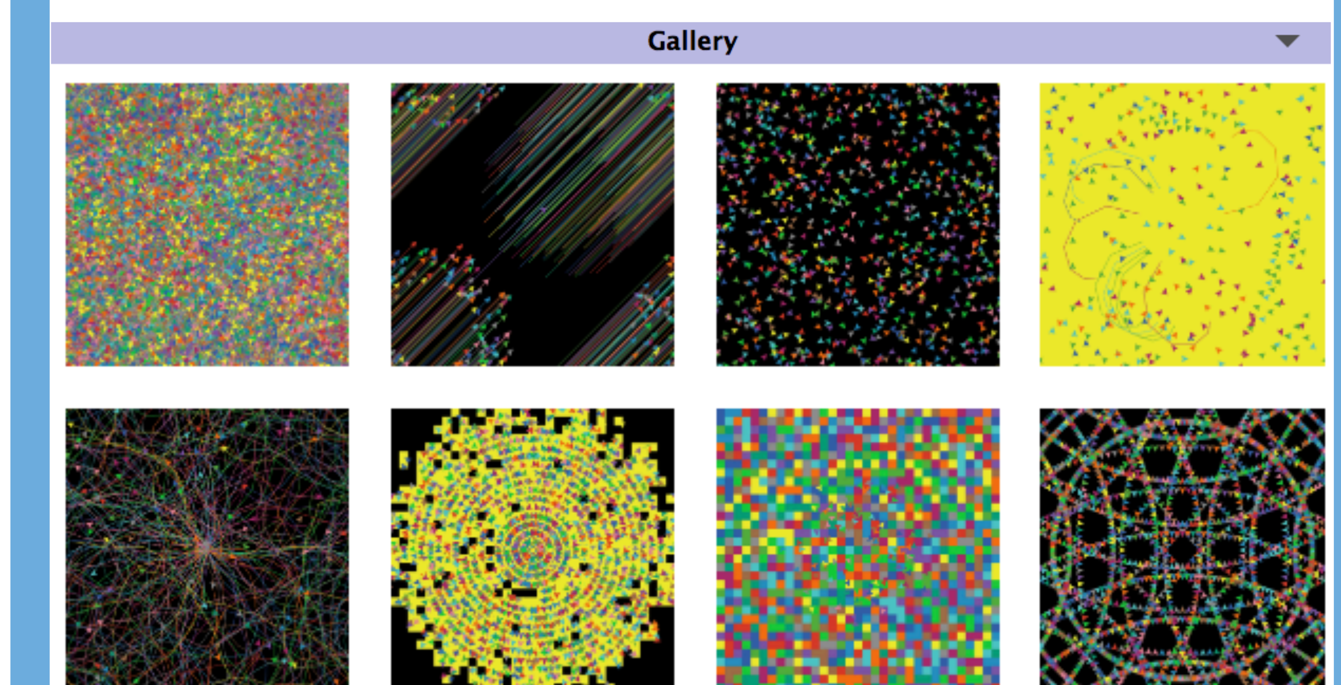

***Figure 4.* Cloud-Based Gallery of Shared Student Solutions**

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