

# RoomCast: Distributing Digital Resources in the Classroom of Things

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**Abstract:** RoomCast is a web-based learning resource distribution tool designed to support whole-class collective inquiry in multi-activity instructional units designs enacted on heterogeneous collections of personal and public devices in classrooms. As a design tool, RoomCast supports accommodation to local curricular adaptations and technology platform availability, enabling the configuration of curated learning and teaching resource collections over a broad range of classroom contexts. In the classroom, RoomCast offers rapid redistribution of resources during teacher-initiated activity transitions, automatically distributing tailored sets of resources needed for the activity to heterogeneous client portals. While informed by research in technology supports for orchestration, RoomCast is not intended as a scripting tool for complex activity sequences. Rather, it is designed to support coarse-grained activity structures involving diverse types of stakeholders, placing responsibility for detailed activity management in the hands of teachers or custom scripts, in pursuit of a descriptive framework accessible to practitioners.

## Introduction

In our research over the past several years we have developed and refined collections of digital resources that provide access to “room-sized” simulated objects of inquiry and tools for the collaborative construction of knowledge in whole-class investigations (Moher, 2006). The curriculum units that utilize these resources involve multiple activity segments enacted over weeks or months requiring distinctive resources for different activities and participant roles, delivered via coordinated suites of spatially distributed public and personal devices positioning the “classroom of things” as a composite community user interface.

Over time, we found ourselves reusing those resource collections in a variety of contexts—to support different learning goals and instructional designs, to accommodate differences in available device inventories in classrooms, and to construct contrastive research treatments. In order to reduce software redevelopment effort, we began development of software that would allow our research team to define and implement declarative *resource distribution plans* based on classroom activities and stakeholder types without the need for procedural programming. The outgrowth of that effort is a web-based system, *RoomCast*, that offers customized portals to multiple stakeholders—learners and teachers, but also designers, administrators, researchers, domain specialists, and researchers—working collectively on a curriculum unit using a curated collection of interoperable digital resources. We have used RoomCast to support the design and enactment of over a dozen curriculum units involving multiple resource suites, divergent instructional designs, and equipment inventories.

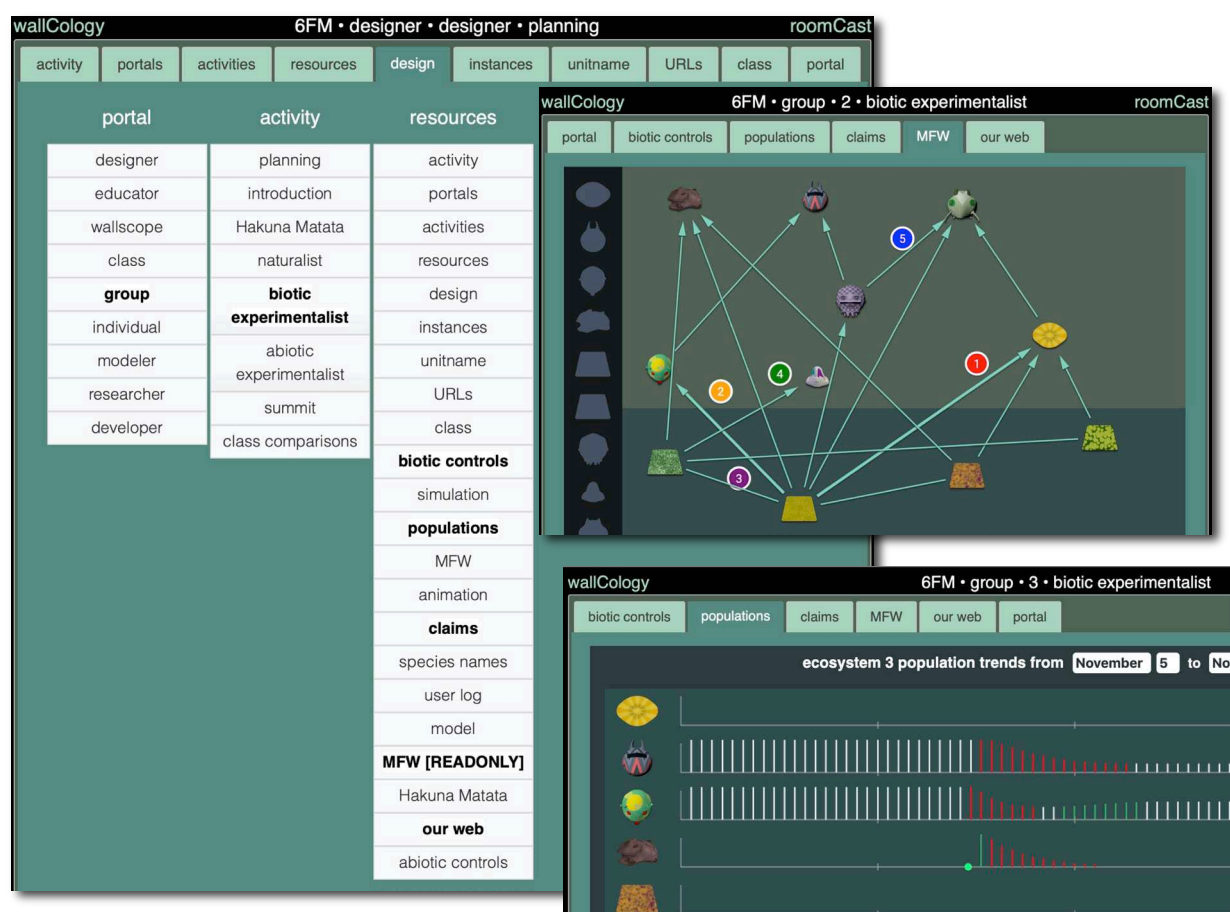
In designing RoomCast, we sought a descriptive framework that would be accessible to non-programmers—ultimately, to practitioners—while still providing enough power to accommodate the variations introduced and encountered in different classroom contexts. It combines orchestration support, allowing teachers to define and enact primo-scripts, with orchestrable features enabling enactment-time introduction and spontaneous use of resources in response to emerging classroom activity (Tchoukine, 2013). As an orchestration resource, RoomCast is best seen as an “arranging” tool (Kollar and Fischer, 2013), affording adaptive configuration of reconfigurable learning and teaching resources. RoomCast draws from contemporary research in scripting systems in its adoption of components including roles, resources, and activities (Kobbe, et al., 2007) as basic structural elements, introducing a menu-based interface as an alternative to table-based view (Wang, et al., 2018) to specify a three-dimensional configuration (portals, activities, and resources). RoomCast is not designed to directly structure collaboration among learners at fine grains of activity found in systems such as Collage (Hernández-Leo, et al., 2006), Common Knowledge (Fong & Slotta, 2018) or FROG (Håklev, et al., 2017). While RoomCast affords the specification of resource distribution in a way that could support many collaborative flow learning patterns (CFLP, Hernández-Leo, 2005) as in Collage, it does not provide such patterns as primitive elements, nor does it provide teachers with assistance in selecting patterns based on their pedagogical benefits.

In the following, we draw on examples of the use of RoomCast in the design and enactment of distribution plans that utilize of a set of coordinated resources supporting investigations of population dynamics in simulated ecosystems. In WallCology (Moher, et al., 2008; Cober, et al., 2012), classroom communities

observe and manipulate distributed (simulated) ecosystems imaged to occupy the walls of their classrooms, collectively uncovering energy exchange relationships and constructing community models that allow them to predict the impact of biotic and abiotic perturbations of their ecosystems. The WallCology suite includes a rich set of interoperating resources: animations of simulated flora and fauna, controls for manipulating ecosystem properties, tools for capturing and representing population histories, forms for submitting evidence-based claims about energy relationships, graphic tools for drawing and annotating food webs, computational models for controlling the simulation, and many others. Below, we briefly describe how distributions plans are specified in RoomCast, offer examples of distribution variants that we have implemented using RoomCast, and discuss opportunities and limitations associated with our approach.

## RoomCast overview

The specification of a RoomCast *resource distribution plan* begins with the specification of the digital web *resources* to be used during the curriculum unit; these resources may include both components of a coordinated suite and stand-alone web pages. In pursuit of simplicity, RoomCast adopts a “one page, one resource” strategy rather than affording component-level design, and offers a uniform tab-based interface style to all stakeholders. The next task is to name the *activities* comprising the unit and the *portals* reflecting the types of stakeholders who involved in the design and enactment of the unit. Finally, the designer constructs a distribution *design* that specifies the resources to be distributed for each portal-activity pair. Figure 1 (left) shows a (partial) resource distribution plan for an eight-week enactment of a WallCology unit in fall 2018, specifying the resources that will be distributed to 'group' portals (shared tablet computers) during the 'biotic experimentalist' activity.



**Figure 1.** Partial distribution plan for a WallCology (population dynamics) unit.

Because RoomCast is designed to support synchronized, whole-class work rather than independent individual progression through an activity sequence, at any given time all clients are operating under the same activity rubric. RoomCast activities are not (necessarily) enacted in consecutive fashion; they represent

modalities of activity rather than steps in a pre-defined sequence. Figure 1, for example, includes a 'summit' activity used at multiple points during enactment of the curriculum unit. Control over activity selection is in the hands of the teacher rather than an underlying sequencing engine.

Participation in a RoomCast begins with the acquisition or selection of an available device and an intention to use that device to serve as a particular kind of portal into the enactment. This defers the binding of a specific device to the immediate moment of enactment, and readily accommodates device swapping necessitated by device failures or serial sharing between class sections. The recruitment of a device serving a public roomCast portal may be selectively initiated by any of the stakeholders, providing an opportunity for teachers to enlist students as collaborative managers of community technologies. This recruitment mechanism also invites concurrent portals of the same type. In roomCast, all portals of the same type share access to copies of the same set of resources, but interact as individual *instances* of that portal within the roomQuake enactment environment, and may contribute instance-attributable data to an enactment's shared data collection. There are no restrictions on the number of instances of each portal type; this is well suited to the use of participant (e.g., students) and public (e.g., seismographs) portals, although it requires social mediation to impose serial regimens with administrative tools whose use might create database "race" conditions, with concurrent administrative portals overwriting an enactment's "global" environment parameters.

## Supporting local adaptation

In the earliest enactments of WallCology, prior to the development of RoomCast, the determination of species population estimates played an important role in community work. Students were challenged to estimate populations by observing and actively counting individuals in dynamic animations of small window (wallscopes) into a classroom wall, and then estimating the populations within the whole wall by multiplying those counts by the ratio of the wall-to-window area ratio, and document those estimates through incremental additions to population graphs drawn on large poster sheets on the classroom wall. No individual or group devices were used. Groups developed different strategies for counting—dividing the screen into quadrants assigned to team members and merging results, or assigning different team members to different species—that became the subject of class discussions. Perturbations of the ecosystems were effected externally, in the form of global changes to abiotic (e.g., an increase in moisture due to leaking pipes) and biotic (e.g., the introduction of new, invasive species) conditions. The culminating activity involved the development of a whole-class consensus around an abiotic intervention—performed by researchers—to mitigate the impact of the invasive species, and an evaluation of the effectiveness of that manipulation. A RoomCast-based version of this instructional design could simply assign the *animation* resource to wallscopes, and provide the teacher's portal with the *abiotic* and *biotic* control resources for effecting the perturbations.

More recent WallCology enactments have focused on population dynamics and the determination of energy exchange relationships among species, with the goal of constructing a "master food web" depicting direct relationships among the community of species found in the collective ecosystems. In these units, students observe and directly manipulate local ecosystems, developing and submitting evidence-based claims about relationships to a shared database. Because of the change in learning goals, populations are no longer counted by students, but rather provided "automatically" through longitudinal graphs. A RoomCast configuration to support these enactments moves the ecosystem control and claims construction resources to workgroup portals hosted on tablet computers, and adds the 'population graphs' resource to the wallscopes to complement the ecosystem animation. For classrooms with fewer devices, the wallscope portals could be provided with all of these resources, eliminating the need for tablets altogether.

RoomCast has also proven useful as a tool for investigating contrastive research treatments. In a recent project, we restricted access to peer group claims in one classroom to periods when the full class was engaged in "summits" in which they evaluated peer group claims and updated the emergent community model. The goal in that treatment was to ensure that all peer group claims were considered within the context of the full community. In that classroom, we assigned the "master food web" to the teacher portal only. In the other classroom, a read-only version of the master food web was made available on work group tablets, affording groups with access to peer claims when students were working in groups around their local ecosystems.

## Opportunities and limitations

We believe that RoomCast strikes a promising middle ground between usability and expressive power. RoomCast imposes a demand to construct a three-dimensional specification. It would, of course, be possible to condition resource availability on criteria beyond portal type and the current class activity. Variables such as a user's location (e.g., physical proximity to a Bluetooth beacon), state (e.g., earned badges), or time of day (e.g.,

before or after lunch) could all be included as determinants, but at a combinatorial cost in the complexity of distribution plans, as each variable introduces a new dimension to the specification.

Who authors distribution plans? The adaptability we seek to offer requires that teachers become involved in developing and modifying distribution plans. While ambitious teachers might eventually create plans "from scratch" around resource collections, we envision the availability of indexed databases of reusable distribution plans, developed by curriculum designers (or other teachers), that teachers could use modify to adapt to local contexts. We have recently begun to design a RoomCast professional development program that would focus initially on frequently occurring enactment scenarios (e.g., adding new students, responding to device breakdowns), and the move through a progression of configuration resources (defining new activities, introducing new portal types) to build expertise. In addition to instructional designers and teachers, RoomCast is also intended for researchers; in our work, we have leveraged RoomCast to facilitate resource reuse across design revisions and to introduce and enact design variants for experimental research.

RoomCast is designed to reduce the costs in class time associated with activity and class transitions (Dillenbourg, 2013). The 'educator' portal includes the 'activity' resource that can be used to change the activity at any time, causing each client portal to be updated to reflect the resource set appropriate for the new activity. This obviates reconfiguration of public devices, and allows learners to transition among activities without the need to close and open applications.

RoomCast hints at a development strategy focusing on the growth of multiple instructional designs around curated disciplinary resource sets. In our work, we have partnered with scientific experts in developing resource suites embodying disciplinary practices and epistemic forms that we have been able to "mix and match" using RoomCast, allowing us to support multiple curricular designs without the need for extensive re-programming. This represents a more limited domain of reuse than that afforded by crosscutting tools such as the Concord Consortium's SageModeler and SmartGraph resources, but one that allows a tight focus on disciplinary forms and facilitates the construction of interoperable resource suites.

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