Abstract

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Approaches to Processes of Construction in Software Kits

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Abstract

We have developed a genre of software construction kits and a framework for implementing them. The framework is both conceptual and structural. Its conceptual aspect derives from constructivist learning theory, and its structural aspect extends the Java Abstract Windowing Toolkit. This framework, called the “Kit4Kits,” supports generation of software kits that are highly graphical and highly interactive. They are characterized by two main processes: players’ building of objects from graphical elements, and the software's activation of the constructions. Five existing kits demonstrate a range of techniques for constructing objects. Additional techniques have become apparent as users of the framework created their own kits. We review these results and discuss various techniques for constructing graphical, dynamic, two-dimensional objects in software tools for learning.

1. Introduction

We are developing a series of software kits based on the notion of “microworlds” [7] and the theory of “constructionism” [4, 5]. In this view, people construct rather than acquire knowledge, actively inventing ideas for themselves. Idea invention (or knowledge construction, or learning) is based on internalization of actions and experiences in the world [3]. Therefore the nature of particular activities becomes interesting, and activity design has become a specialization in learning research. Many of the designs find broader application in real-world domains such as toys, puzzles, and software [e.g., 8].

Considerations in activity design and interaction design are guiding development of our software construction kits. They form a genre in which end-users build and activate 2D graphical objects [11, 15]. Dinosaur skeletons balance as they walk and run [10]; maps transform into street-level views [12, 14]; colorful tiles spread into geometric patterns [2]; animistic creatures simulate the push-pulls of social dynamics [1, 2]; and dancers’ breathing rates form a cycle for a shared dance [17].

These kits focus on subject domains as varied as geometry, symmetry, physical forces, mechanical structures, time/space relationships, and system dynamics; yet they incorporate common strategies in activity design and interaction design. We are currently formulating generalizations of the strategies and programming constructs to support production of further instances of the genre. The resulting Java framework, called the “Kit4Kits,” is both conceptual and structural [15, 16].

The Kit4Kits is comparable to systems like Microworlds, Cocoa, Agentsheets, ToonTalk, Squeak, and other tools for developing simulations and game-like learning environments.* However, we pay particular attention to notions of conceptual elements and operations as characterizers of an epistemological domain [7, 13]. We also tend specifically to computational supports for image treatments such as transparencies, filters, and gradients.

In our kit designs, and in kits that others have developed using the Kit4Kits, we have noted interesting variations and outstanding problems pertaining to a key facet of interaction design for the genre. Primarily, the kits support players’ constructions of graphical objects, which upon activation become animate in some way. Players effect the constructions through direct manipulation of graphical elements, but the manner of access and assembly of the elements varies from kit to kit.

Here we review varying construction techniques for our existing prototypes, report on additional construction techniques developed by trial users of the Kit4Kits, and identify considerations for further construction techniques.

2. Existing Prototypes

2.1 Bones

In the Bones kit, the player creates skeletons by dragging individual bones into the work area and arranging them into the form of a dinosaur. The player can then animate the construction.
Bones players assemble parts into skeletons and then animate the creature. The software locates the construction’s center of mass in order to determine whether the creature can balance as it moves.

In the first version of the prototype [10], clicking any of the movement buttons (“stroll,” “hurry,” or “dash”) triggered several calculations. The program compared upper and lower portions of the composition and made guesses about which bones constituted the skeleton’s legs. Then the program compared the combined mass values of the bones in the upper portion of the construction to those in the lower portion, and if the upper portion was too heavy the skeleton collapsed. Finally the program calculated the location of the skeleton’s overall center of mass and illustrated it with a line projecting downward. If the line fell within a polygon connecting the points of contact with the “ground,” the creature was deemed balanced and it proceeded to move, its legs swinging according to a gait pattern appropriate to the speed and the number of legs. If the line fell outside of base polygon, the skeleton collapsed.

Unfortunately the Bones algorithm could not always decide correctly which pieces constituted the legs, so some peculiar animations resulted. We made a revision in the current version of the prototype, such that designating the legs is part of the construction process. This ensures that the algorithm has the proper number and locations of legs, but shifts a burden to the player, whose freeform construction process is now encumbered by the specification process prior to seeing the animation.

WayMaker

In the WayMaker kit we provide specific parts for building city layouts, but also allow for their further specification. The player arranges representations of districts, edges, paths, landmarks, and nodes into the form of a map, and the software generates street-level views along pathways through the mapped domain while maintaining the relative placements of the elements [12, 14]. However the elements are represented abstractly: landmarks are triangles, paths are dotted lines, and so on. The player can substitute more detailed representations: triangles can become towers, bridges, houses, etc.; lines can take on the look of textured terrain, etc.

PatternMagix

In PatternMagix a four-part grid supports exploration of geometric symmetries as players reflect tiles around the x- and y-axes and rotate tiles within quadrants [2].
Figure 5. PatternMagix players experiment with reflections and rotations. The software replicates a resulting tile, and surprising patterns emerge.

2.4 AnimMagix

In AnimMagix a tripartite column guides assembly of animistic creatures’ perceptual, social, and mobile behaviors [1, 2]. Sliders enable further adjustments, such as to the degree of a behavior. Perceptual fields can be deep as well as broad, attraction can be strongly or mildly positive or negative, and sweeping movements can be slow or fast.

Figure 6. AnimMagix players work within a tripartite column to specify ways in which creatures will interact with one another.

This manner of construction is familiar from toys, books, and other media. It constrains the construction process but has the advantages of providing pre-established designations for the algorithm and helping to clarify how the player should go about making a construction.

Figure 7. Other playthings make use of a similar manner of construction. 2

2.5 Zyklodeon

We are employing a similar technique for a prototype now in progress, Zyklodeon, in which players create humanistic figures and endow them with properties that effect timing for a shared dance [17]. Dancers comprise six parts: head, torso, arms, and legs. Changing from a default part to a more colorful representation is similar to element specification in WayMaker, though the overall construction process is simpler because the defaults are already in place. In Zyklodeon we add a third tier to the construction process: within the torso are slider-controlled settings, like those in AnimMagix, with which the player can adjust a dancer’s breathing rate and other choreographic parameters.

Thus our existing prototypes exemplify a range of construction strategies: freeform construction, freeform construction with a specification phase, structured construction, and structured construction with varying levels and manners of further specification. What remains constant from one prototype to the next is the importance of the relationship between the build and activate processes, which typically plays out as an alternating pattern, usually with greater player control in the building and greater algorithm control in the activating.

Acknowledgment of this pattern led us to create separate structures for the two functions within the Kit4Kits. The Composer and Arena structures identified the nature of the activity within a specific screen area. Composers typically handled building elements; Arenas handled constructions and the associated algorithms that activated them. We explored the usefulness of these structures with several kit creators.

3. Kits by Initial Users of the Kit4Kits

3.1 Abacaudio

Alex wanted to make a kit with which players could create timing relationships in the context of music-making. Ball and soundpad elements would be paired such that a ball falling on a soundpad would make a sound, which could be specified as a particular tone. Building would consist of adding paired ball/soundpad elements to the Composer. Upon activation, each ball would strike its soundpad, and the Arena would display the strike patterns in a graph-like notation resembling a musical score. The patterns could be saved for replay.

Most notable about Alex’s design is that, as in Bones, the build and activate processes share a screen area but constitute quite distinct activities. Thus our Composer and Arena constructs were suitable for his design.
3.2 WordBuilder

Max and Jan began a kit with which players can build letter combinations into phonemes, and phonemes into words. The player progresses downward through a process of word building: letters combine to form phonemes, which become syllables that form words. Letters must match according to particular sonority rules in order to form a phoneme [6]. Matches are saved into pockets ordered according to proper position of the phoneme within a word: an onset phoneme combines with a vowel to begin a word, which ends with a coda syllable. Saved words may or may not yet appear in an English dictionary, but must follow the onset-vowel-coda pattern.

Figure 9. The WordBuilder design evolved through several arrangements of screen areas and corresponding work flow.3

Max and Jan carefully separated the screen areas according to each of these functions, yet the main areas support both building and a kind of activating, which takes the form of checking for proper letter matches and syllable patterns. Nevertheless Jan implemented both areas by extending our Composer structure, rather than using the Composer for one and the Arena for the other.

3.3 Bugs

Chris wanted to make a simulation kit that would deal with notions of ecology. He wanted players to be able to control aspects of the environment, which resembles an ant farm, and creatures that inhabit it, which he called “bugs.” He separated the two modes into screen displays that differed somewhat but also contained constant features.

Figure 10. Each of the two modes in Bugs includes both build and activate processes.

In environment mode, the player can add bugs and food while the simulation is running. This is a kind of constructing, since the environment becomes more elaborate, but it is also a kind of activating, since behaviors play out over time.

Figure 11. The environment mode in Bugs

In bug mode, the player can specify rules governing bugs’ properties and behaviors, such as being hungry, seeking or avoiding food, seeking or avoiding other bugs, seeking food stores, dying when hungry and not finding food, and so on.

Figure 12. Sketches for guiding bug-building in Bugs

At first Chris represented the rule structure as a kind of logical chart, but through discussion he moved to more graphical representations of the settings.

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3 Graphical letterforms are from [9].
This notion of building is similar to the specification phase of building in our prototypes. Chris implemented this functionality by extending the Composer structure.

4. A Typology of Construction Techniques

By working with these kit creators, we realized that the Composer and Arena structures initially in the Kit4Kits overspecified notions of building and activating. Now a more general Zone structure allows for varying notions of building and activating, which may be interrelated in some designs.

Experiences with our kits and those devised by Kit4Kits users has called attention to different kinds of building that learning environment designers may want to support. Including different kinds of building may be a good way to address different learning and thinking styles. Structures that guide building can be useful when constructions within a kit take a consistent form. Phased construction may include sub-processes such as specification of behavioral properties and image details.

While providing a set of building elements inevitably constrains what players can make with a given kit, interaction designs may range from encouraging recipe-style production of particular constructions to freeform building that relies on the player’s creativity. We prefer open-ended building in which players produce novel constructions but note that younger builders and builders of complex constructions may benefit from guided processes such as construction grids and phases. Other interesting possibilities include reversing a construction process for an existing object and adjusting or completing a partially started construction process.

5. Acknowledgments

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6. References

