

Using a Barrel of Monkeys in Computer Science

James K. Huggins

Kettering University, 1700 W. Third Avenue, Flint, MI 48504-4898
jhuggins@kettering.edu

Abstract - The use of tangible models in the classroom (at all levels of instruction) is incredibly common; CS instruction is no exception. In this report, we discuss experiences in using the common *Barrel of Monkeys*® toy to teach concepts related to dynamically allocated linked lists. Points of emphasis include pointer vs. object distinctions, copies of pointers, list manipulation algorithms, memory allocation and leaks, and classroom presentation tips.

Index Terms - Classroom examples, Linked lists, Models, Toys

MOTIVATION

The use of tangible models in the classroom (at all levels of instruction) is incredibly common. Computer science instruction is certainly no exception; the computer science education literature is filled with examples of toys and models used to demonstrate various key concepts.

Kettering University's CS-102 course, like many traditional CS2 courses, has as one of its foci the concept of dynamically allocated linked lists. In the classroom, traditional means to present and reinforce the topic are often used: comparison with array-based lists, traditional "box-and-arrow" pointer diagrams (used in many textbooks, e.g. [1]), and of course implementation code.

Several years ago, the author started referring to the classic *Barrel of Monkeys*® toy during presentations of the concept of linked lists. An attempt was made to evoke students' memories of the toy as various concepts were discussed. (It seems that more students remember the toy from its cameo appearance in *Toy Story* [2] than from playing with it themselves.) After several such attempts, a copy of the toy was obtained and has been used with great success in the classroom since that time.

HISTORICAL BACKGROUND

For those not familiar with the toy, the standard *Barrel of Monkeys*® consists of a large number of individual monkey pieces, each about 7cm by 5cm in size. Each monkey has its arms extended in a hook shape in opposite directions. These arms can easily be interlinked to form a chain of monkeys, which is the intended use of the toy. Imprinted on the barrel are instructions for a couple of simple games. (See Figure 1.)

The concept of a "barrel of monkeys" seems to have its origins in the common idiom "more fun than a barrel of monkeys". The idiom dates back to at least 1895, and appears



FIGURE 1

THE BARREL OF MONKEYS® TOY. (PHOTOGRAPH USED WITH PERMISSION OF HASBRO, INC.)

to have the obvious meaning, referring to the observed playful behavior of monkeys [3].

The *Barrel of Monkeys*® toy was first manufactured by Milton Bradley in 1966 [4]. Milton Bradley was acquired by Hasbro in 1984, which retains the registered trademark.

DEMONSTRATION

The toy can be used straight out of the package. A typical use involves building a chain of five or six monkeys and hanging them from a finger on one hand, holding the chain up high enough for students to see. This immediately illustrates one key point: the pointer/reference (hereafter "pointer") to the first item in the list gives one access to the entire data structure. Lifting and lowering that pointer finger, and thus the entire chain, illustrates that fact dramatically.

This also establishes a dramatic visual difference between objects (the monkeys) and pointers (the human fingers or monkey arms that attach to monkeys). In particular, using a finger as a representation of a pointer is very natural, since fingers are a natural pointing device (perhaps the original one).

One point of awkwardness that became apparent after a couple of uses comes from the uniform appearance of the monkeys. Each monkey is made from the same red plastic; while this re-affirms that each node is just like any other node, it becomes awkward when discussing algorithms involving multiple different nodes. ("To insert a monkey at *this* point in the list, you have to change *this* pointer to point *here*, and then *this other* pointer to point *here*.") Using spray paints can create a variety of colors, allowing for disambiguation of nodes in a given list. ("To insert a blue monkey between the white and red monkeys, you make the blue monkey point to

the red monkey, and then you make the white monkey point to the blue monkey.”) If possible, bright, contrasting colors should be used.

While working with chains of monkeys, especially in front of a group of students, it is extremely easy to drop monkeys on the floor. This is actually beneficial. It reinforces the fact that pointer manipulation creates the potential for losing access to allocated nodes (after all, there are no fingers pointing to the monkeys on the floor). The monkeys lying on the floor are easily described as “garbage”, whose eventual disposition may be handled by a “garbage collector” (or, alternatively, lead to no more monkeys being available). And, of course, students always enjoy laughing at (with?) their instructors when things go wrong. (It is easy to get a little *too* good at manipulating chains of monkeys; one may wish to deliberately drop a monkey or two on the floor at key moments.)

Obviously, due to the relatively small size of the monkeys, such demonstrations are better suited to small classrooms. In larger classrooms, one should consider using some sort of simple projection equipment (a webcam attached to a projected computer may be sufficient).

Technically, a chain of monkeys models a doubly-linked list more closely than a singly-linked list, since each monkey has two arms. This distinction can be easily ignored at first (few students seem to notice this distinction); the distinction can be highlighted later as time permits.

Any number of possible enhancements could be made. The “barrel” could be viewed as a model for a memory heap, holding a collection of different yet equivalent nodes for available use. The “bodies” of the monkeys could be enhanced to store actual data (perhaps by attaching items of interest to the monkey bodies). Other ideas undoubtedly exist.

EVALUATION

The author has used this toy for several years in Kettering University’s CS-102 course, which covers traditional CS2 topics including linked lists. Students are exposed to both the toy and traditional algorithmic descriptions of linked lists, and then asked to demonstrate their understanding of the concepts through writing programs and formal examinations.

An informal, unscientific survey of roughly 100 former students was conducted by the author via electronic mail. All students had seen the demonstration in Kettering University’s CS-102 class with the author, some as long as two years prior to the survey.

Roughly a quarter of the students responded to the survey. All stated that they remembered the demonstration and the corresponding concepts. All found the demonstration effective in conveying the key concepts. Selected student comments follow.

- “Linked lists can be pretty confusing, and that visual aid is just about a perfect way to represent how they work, and easy to understand.”
- “I found it much more effective than drawing and erasing or redirecting arrows on a board, which can get cluttered and confusing.”

- “I had already done things with linked lists prior to CS-102, so I can’t really say how helpful it was for learning it as a new concept, but it was the best way I had heard it explained.”
- “Since I haven’t used Java since that class, I don’t think I would be able to remember all of the details of how to make a linked list work in Java. However, I still definitely remember the concepts due to the barrel of monkey’s example.”
- “They definitely helped keep my attention more than a purely ‘theoretical’ explanation would have. I have to admit, however, that when I work with Linked lists now, I don’t think of monkeys. . . .”

While such evidence is anecdotal, it seems clear that the use of the toy helps students learn the corresponding concept, and retain that knowledge over time.

RELATED WORK

The use of toys in the classroom to demonstrate important concepts in computer science seems anecdotally popular; at the same time, there appear to be few documented uses of such toys in the literature. Indeed, the word “toy” is often used as a perjorative term in the literature, referring to programs or projects that are overly simplistic and therefore unrealistic. The specific use of the *Barrel of Monkeys*® toy appears not to have been previously discussed in the literature.

Astrachan [5] discusses the use of several different props in the classroom to illustrate important concepts in computer science. Flying discs are used to illustrate parameter passing; interlocking plastic blocks are used to illustrate linked lists; Klutz’s “Icky Poo” is used to illustrate pointers.

The text *Computer Science Unplugged* [6] contains numerous examples of games (most involving props) that can be used in K12 education to illustrate various CS concepts. Most of these props are custom-built for each activity; many of the activities could be used with college students with equal success.

Bergin *et. al.* [7] mention plastic block versions of linked lists as an example of algorithm visualization, as they advocate for the use of visual tools in helping students build mental models of key concepts. The emphasis of their paper is on computer-based simulations (*e.g.* animations) rather than physical toys.

More recently, the LEGO® MindStorms™ toy has been promoted as a tool for teaching algorithms via a robotic toy. Many papers have been written on the subject; see for example [8], [9], [10].

CONCLUSION

The *Barrel of Monkeys*® toy can be used effectively within the computer science classroom to teach concepts related to linked lists. The toy can be used with minimal additional effort. Students report that this visualization of the abstract concept of lists aids in their comprehension of the concepts and in retention of those concepts over time.

ACKNOWLEDGMENT

The author first presented this material at the “Toy Night” session of the 2004 Advanced Placement Computer Science Reading in Clemson, SC, organized by Robert Duvall. Thanks to Fran Trees for suggesting the idea of this paper, and to the anonymous reviewers for useful suggestions.

Barrel of Monkeys ® & © 2005 Hasbro, Inc. Used with permission.

REFERENCES

- [1] Standish, T., *Data Structures in Java*. Addison-Wesley, 1998.
- [2] “Toy Story,” Walt Disney Pictures, Pixar Animation Studios, 1995.
- [3] Ammer, C., *American Heritage Dictionary of Idioms*. Houghton Mifflin, 1997. (Accessible via <http://dictionary.reference.com>.)
- [4] “Milton Bradley company history,” http://www.hasbro.com/pl/page.corporate_history_mb.
- [5] Astrachan, O., “Concrete teaching: hooks and props as instructional technology,” in *ITiCSE '98: Proceedings of the 6th annual conference on the teaching of computing and the 3rd annual conference on Integrating technology into computer science education*. New York, NY, USA: ACM Press, 1998, pp. 21–24.
- [6] Bell, T., Witten, I., and Fellows, M., *Computer Science Unplugged*. University of Canterbury, New Zealand, 1998, <http://unplugged.canterbury.ac.nz>.
- [7] Bergin, J., Brodie, K., Patiño-Martínez, M., McNally, M., Naps, T., et al., “An overview of visualization: its use and design: report of the working group in visualization,” in *ITiCSE '96: Proceedings of the 1st conference on Integrating technology into computer science education*. New York, NY, USA: ACM Press, 1996, pp. 192–200.
- [8] Patterson-McNeill, H. and Binkerd, C.L., “Resources for using LEGO Mindstorms,” in *Proceedings of the seventh annual consortium for computing in small colleges central plains conference on The journal of computing in small colleges*. , USA: Consortium for Computing Sciences in Colleges, 2001, pp. 48–55.
- [9] Whitman, L.E., and Witherspoon, T.L., “Using LEGOs to interest high school students and improve K12 stem education,” in *Proceedings of the 33rd ASEE/IEEE Frontiers in Education Conference*. IEEE, November 5–8 2003, p. F3A.
- [10] Garcia, M.A., and Patterson-McNeill, H., “Learn how to develop software using the toy LEGO Mindstorms,” in *Proceedings of the 32nd ASEE/IEEE Frontiers in Education Conference*. IEEE, November 6–9 2002, p. S4D.