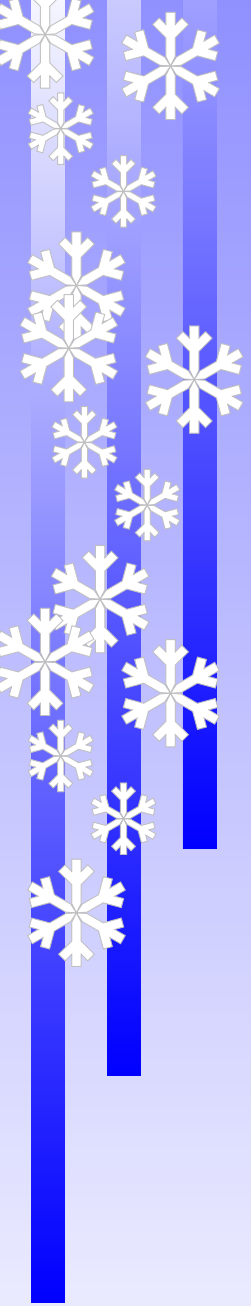

Affective Effects of Program Visualization

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Rehabilitating Marco Polo

Marco Polo presentations: I went there and I saw this.

The reasoning is defined, the component parts are explained, and then (and this is the giveaway for this category) a conclusion is drawn like:

- ✓ Overall, I believe the [topic] has been a big success.
- ✓ Students seemed to really enjoy the new [topic].

David Valentine (2004)

Excusing Visualization

Even if animations do not contribute to the fundamental understanding of an algorithm, they do enhance pedagogy by making an algorithm more accessible and less intimidating.

Kehoe, Stasko and Taylor (1999)

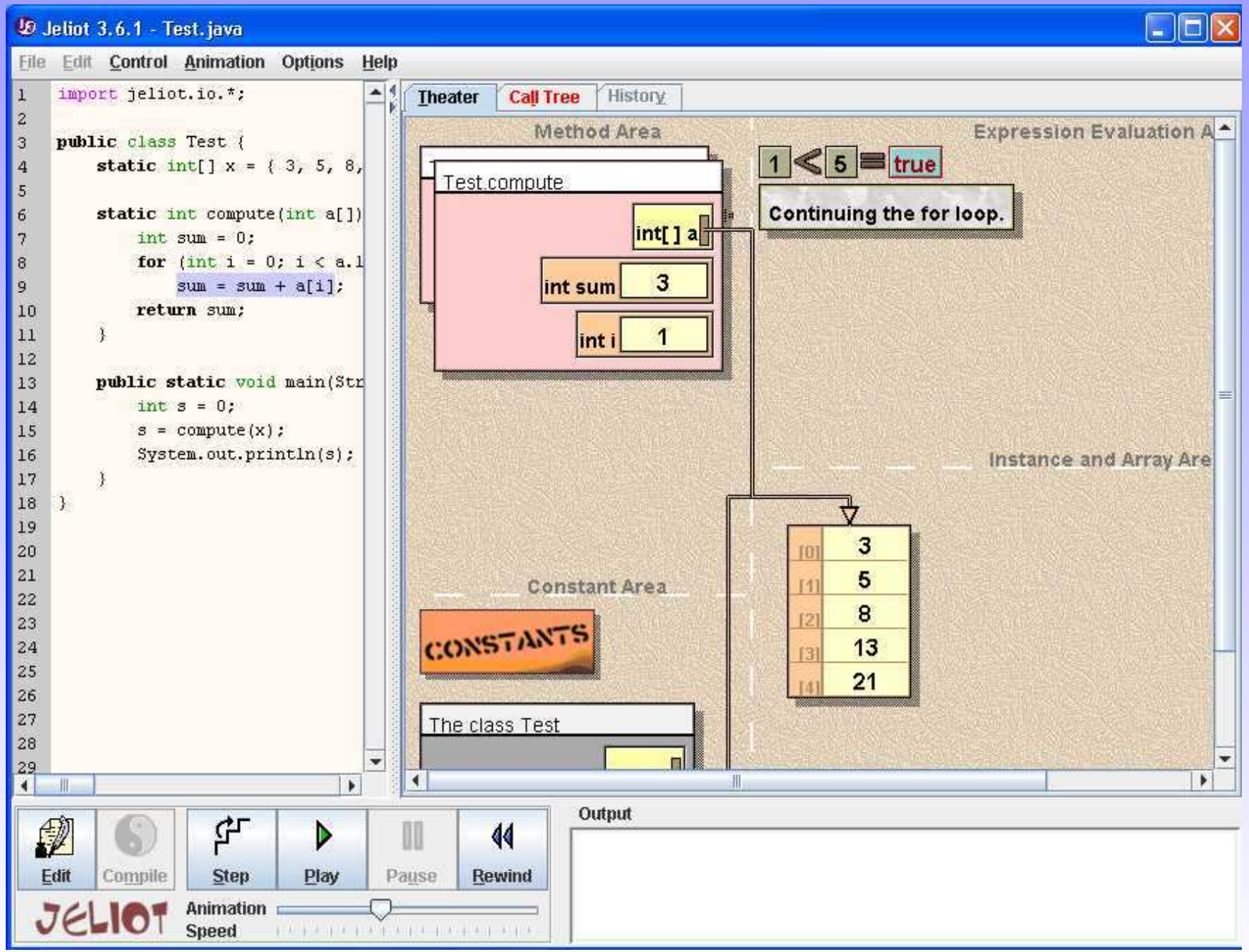
Attention as a Proxy for Learning

- Definition: A student is attentive if “the student is looking where he or she is supposed to be looking,” where “supposed to” is defined as the “explicit or implicit intention of the teacher.”
- Attention is the first step in the learning process. We cannot understand, learn or remember that which we do not first attend to.
- The quality of attention correlates with learning effectiveness; the time students spend paying attention is a good predicator of their achievements.

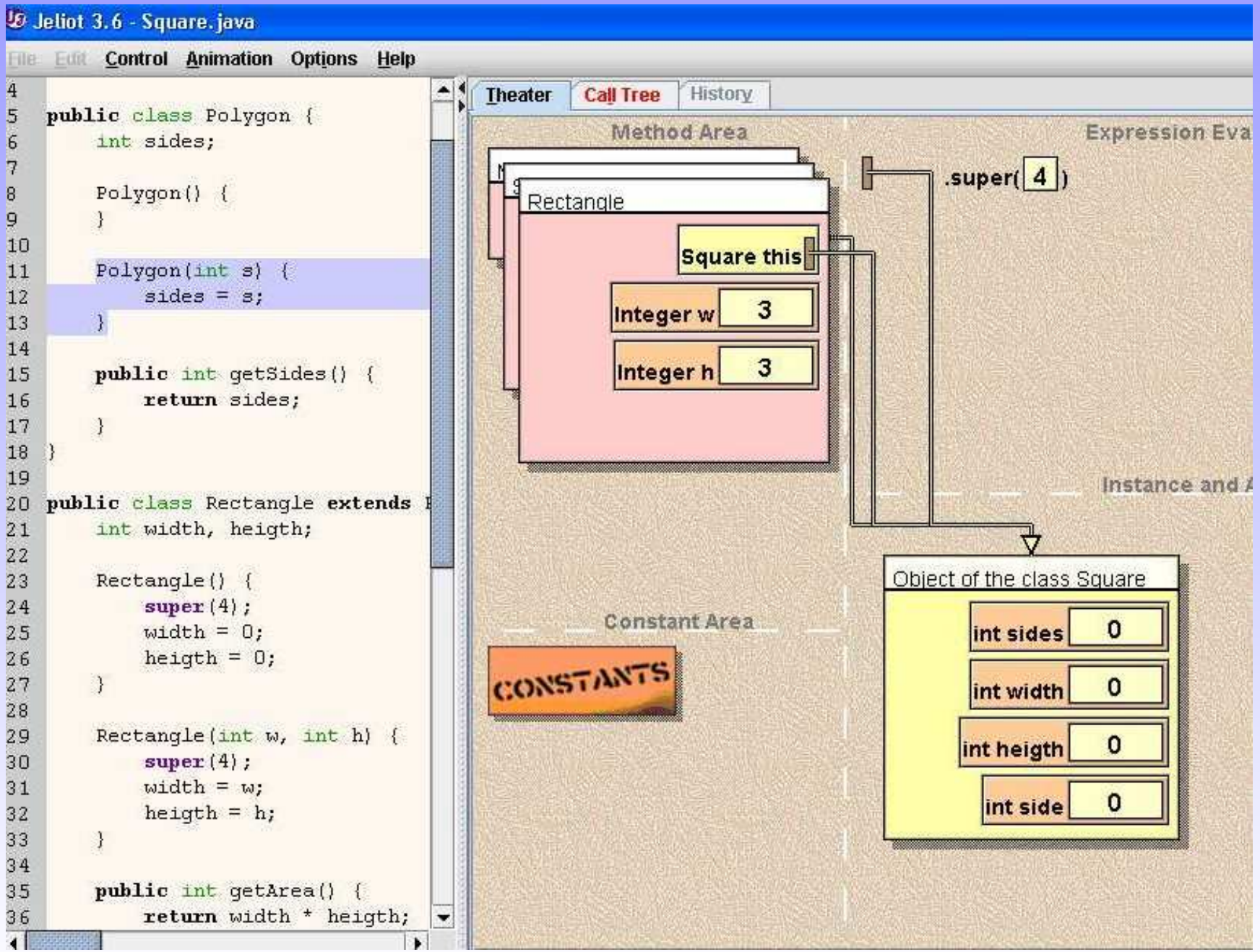
The Jeliot Program Animation System

- Jeliot is designed for teaching the basic concepts of programming to introductory students of CS.
- The creation of the animation is *fully automatic* from the source code; animations can be done on-the-fly.
- Animations are *complete* (every aspect of the program's execution is animated) and *continuous*. Textual explanations of control flow is provided.
- There is an editor and a simple control panel for controlling the execution.
- http://cs.joensuu.fi/jeliot/.

Jeliot—Control Structures



Jeliot—Objects



Research on Jeliot—Ronit Ben-Bassat Levy

- √ Tenth grade introduction to computer science and programming.
- √ An experiemental group received an extra weekly hour of instruction using Jeliot and a control group received equivalent extra instruction without Jeliot.
- √ Significant improvement of learning performance.
- √ Improvement was due to the rich concrete terminology that the animations supplied.
- √ The effect persisted into the second year!

Context and Population

- Ten high-school students studying *Foundations of Computer Science*.
- The students suffer from a variety of emotional difficulties and learning disabilities, including ADHD, but have normal cognitive capabilities.
- Lectures with program visualization administered in the *viewing* and *responding* categories of engagement (Mayer, 2001).
- We used Jeliot to introduce new subjects such as the control flow of if-statements and while-statements.
- The teacher was the first author.

Data Collection

- ✓ Four lessons were video-taped.
- ✓ An observer (not one of the researchers) took field notes in order to observe behavior that may have taken place outside the field of view of the camera, as well as to validate the analysis of the video tapes.
- ✓ In the event, the behavior recorded was so blatant that there was no need to use these independent data.

Data Analysis

- We measured the rate at which unattentive behavior occurred in order to correlate it with the type of activity during which it occurred.
- Unattentive behavior limited to easily recognized "acting-out" behaviors called *Episodes of Recognizable Unattentive Attitude (ERUA)*.
- Criteria:
  - The student is performing an act that has nothing to do with the lesson;
  - The act performed is offensive toward the teacher or another student.

Categories of ERUAs

- ✓ Disputes over objects: A student picks up a ruler from the next table, drops it, get cursed by the owner of the ruler, picks it up and refuses to return it.
- ✓ Disrespect for the teacher: A student teases the teacher in a provocative way about a spelling error or the quality of his handwriting.
- ✓ Deliberate interference with other students: When one student starts to ask a question, another student falls on the table and starts to snore loudly.
- ✓ Calls attention to himself: A student claims that he needs to leave the class *now* or he will do “irrational” things.

ERUA—Stage 1

ERUA—Stage 2

Lesson 1

Activity	Duration	$ERUA_{avg}$
Expert	231	0.25
Frontal	350	0.34
PV	248	**0.00**
Frontal	276	0.65
PV	256	**0.00**
Frontal	811	0.44
PV	310	**0.00**
Frontal	962	0.43
PV	212	**0.00**
Self-study	872	0.20
Student	179	0.30

Lesson 2

Activity	Duration	$ERUA_{avg}$
Frontal	1539	0.30
PV	169	**0.00**
Frontal	1340	0.40
PV	148	**0.00**
Self-study	837	0.07
Student	259	0.00
Frontal	180	0.00

Lesson 3

Activity	Duration	ERUA$_{avg}$
Expert	243	0.00
Self-study	420	0.71
Expert	436	0.27
Frontal	638	0.37
Frontal	785	0.37
PV	378	**0.00**
Frontal	298	0.60
PV	183	**0.00**

Lesson 4

Activity	Duration	$ERUA_{avg}$
Self-study	1114	0.37
Expert	1075	0.66
Frontal	434	0.69
PV	158	**0.00**
Game	609	0.39
Frontal	518	0.81

Discussion

- The ability of PV systems to offer scaffolding mechanisms for meaningful learning could explain why students find that PV contributes to their learning and why they are fond of it.
- The *broaden-and-build theory of positive emotions* states that positive emotions have the ability to momentarily change a person's thought and action repertoire, in particular, "to engage with the environment and partake in activities" (Fredrickson, 2001).

Validity in a Normal Population

- Investigation of pathologies leads to results that are directly applicable to a normal population. The abnormal population is expected to have a higher level of disruptive behavior that facilitated the analysis of the effects.
- Disruptive behavior is also present in normal students, albeit to a lesser extent.
- The *middle-third effect*: Since improved attention and behavior can be obtained through the use of PV, even in a normal class students in the “middle-third” of the scale of attention capabilities are likely to be helped.

The Sesame Street Syndrome

- “It teaches children that there are right answers to many questions, that facts themselves are valuable, that children’s questions are irrelevant, . . . that thinking is irrelevant, because there is no time for it, that making mistakes is bad, and failing should be avoided at all costs.” (Eda LaShan, 1972)
- The availability of laptops and wireless Internet can make it difficult for teachers to retain the attention of students: “[T]here are times when I find that I cannot compete.” (Dennis Adams, CACM, September 2006)
- To what extent can visualizations bring about increased attention to the topic of the lesson?

Conclusions

- ✓ We believe that the behavior modification we observed occurred *because of* the use of PV.
- ✓ The improvement in the students' behavior in itself justifies using PV during classroom sessions.
- ✓ Although we did not show directly that better behavior leads to learning, this would seem to follow from the literature (as well as common sense).
- ✓ We believe that the mutual relationship between the affective and the cognitive will be a fruitful topic of research in computer science education.