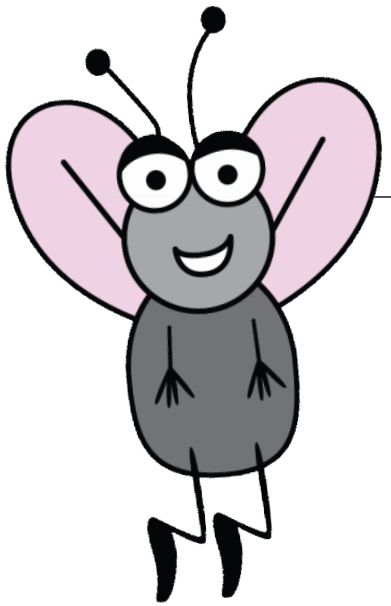
E-Brock-Bugs: A New Free Online Math Computer Game for the Development of Mathematical Thinking



— Integrating Probability concepts in MDM4U

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Fields MathEd Forum, November 30, 2013

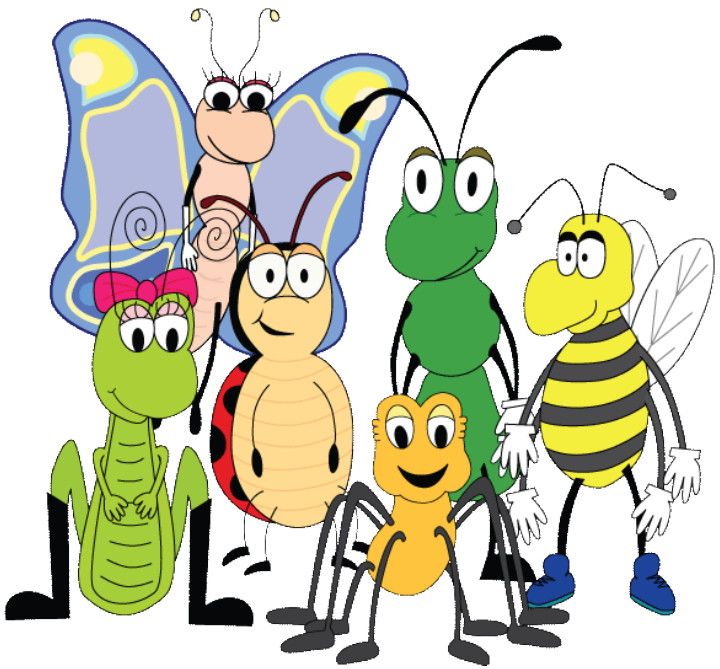
MICA Mathematics Integrated with Computers and Applications

Brock University

Université de Montréal

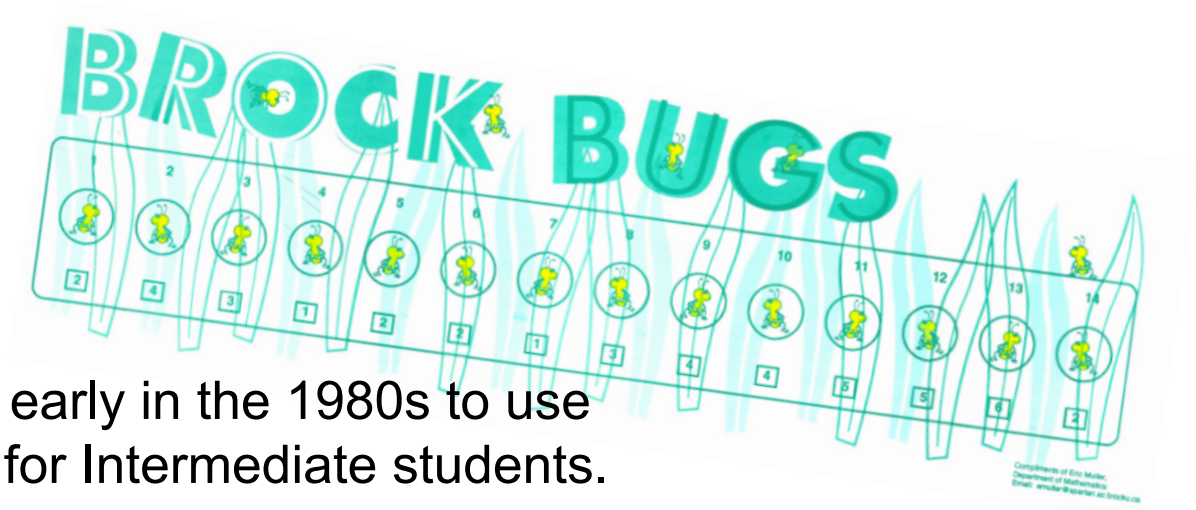
Presentation

- Evolution of *Brock Bugs* game
- Math Computer Games
- **E-Brock Bugs**: new, free, online computer game



The evolution of Brock Bugs to E-Brock Bugs
- important mathematics education constructs that intersects its history –

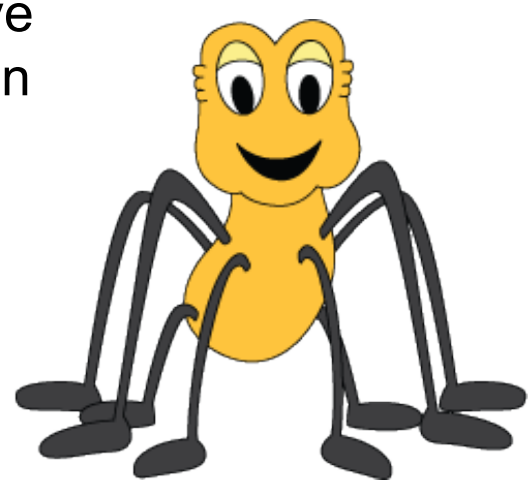
Phase 1 –
A Manipulative



- I invented Brock Bugs early in the 1980s to use in enrichment classes for Intermediate students.
- In this phase the game was used a **tactile manipulative**
- For me the notion of a **manipulative** is self-explanatory, that is, any **tactile** or **digital** item that one can manipulate in order to illustrate and extract a mathematical concept or skill.
- In these Brock Bugs classes I paid special attention to the transition from the game to the mathematics and acted in response to the mathematical development of each individual student.

Phase 2 – Brock Bugs as a Learning Object

- As more probability was introduced into the Ontario curriculum, the Brock Bugs game was revamped into a classroom activity.
- It now included an instruction sheet for students and a separate sheet for teachers and, in the 1990s, was distributed widely to any teacher who requested it.
- This evolution brought the game closer to what is often termed a **Learning Object**
- For me a **Learning Object** is a more comprehensive **tactile** or **digital** environment that mainly focuses on one area or concept in mathematics. Customarily **Learning Objects** include an expert defined sequence of experimentations, often followed by a set of practice exercises and these objects sometimes incorporate assessment.



Other examples of Learning Objects from Brock

- **Learning Objects** were developed in a 2002 summer project by a group of professors, teachers, mathematics and computer science students.
- These can be found at http://brocku.ca/mathematics-science/departments-and-centres/mathematics/resources
- At Brock, future teachers and mathematics majors develop their own digital learning environments (**Exploratory Objects and Learning Objects**)as part of the well established and innovative MICA (Mathematics Integrated with Computers and Applications) core mathematics program.
- Example of student designed, programmed and implemented digital objects are located at the same Web address shown above.
- We believe that future teachers should have the knowledge and experience to change digital **Learning Objects** to meet their own teaching philosophies and circumstances.
- In 2009 Chantal and I built the structure to turn Brock Bugs into a digital learning object. The programming for this object has not been completed.

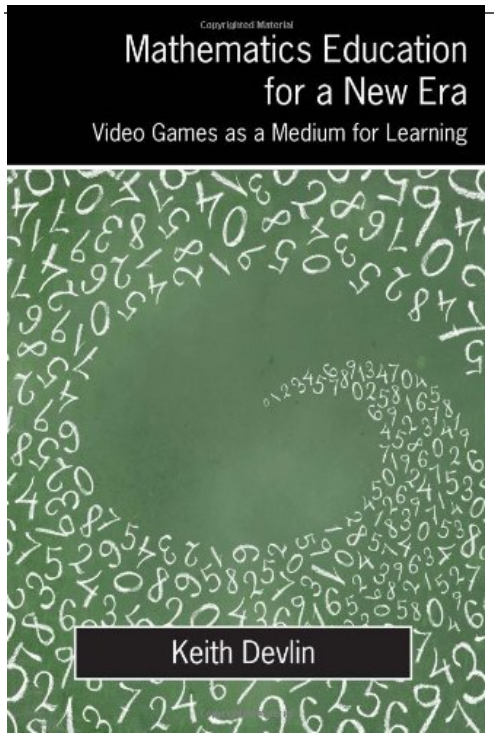
Phase 3 – the Birth of E-Brock Bugs

- In 2011 Keith Devlin published his book (*Mathematics Education for a New Era: Video Games as a Medium for Learning),* where he describes the importance of developing mathematical e-games for learning mathematics.

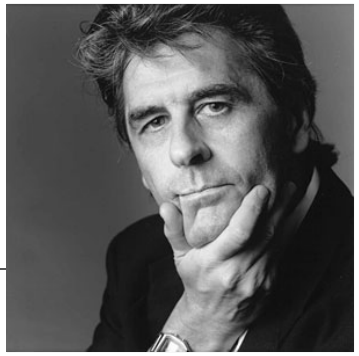
To me:

- **tactile games and e-games** involve play with manipulatives which is dictated by rules but is nevertheless self-directed. Games have
- objectives which can be as simple as reaching a single goal, or as complicated as having to target variable goals that evolve with the players progress. In mathematical games, exploitation of mathematical ideas improves one's ability to reach the goal(s).
- Because of the self-directed property of mathematical games teachers at the secondary and post-secondary levels find them much more challenging to integrate into their teaching of mathematics.
- In 2013 E-Brock Bugs was born and I leave it to Chantal and Laura to describe the incredible feat of getting it on-line in such a short time.

Mathematics Computer Games



Devlin, K. (2011). *Mathematics education for a new era: Video games as a medium for learning*. Natick, Massachusetts: A K Peters, Ltd, 203pp.



‘Hours’ and ‘Hours’ on Video Games

According to 2008 figures from the Pew Research Centre, **97% of today's K-12 students spend many hours** each week playing video games.

By the time they graduate from high school, they will **have spent some 10,000 hours** doing so.

During the course of that game play, they will **acquire** a **vast amount of knowledge about the imaginary worlds** portrayed in the games, they will often **practice a skill many times until they are fluent in it**, and they will attempt to solve a particular challenge many times in order to advance in a game.

What if they devoted some of that time and effort to their schoolwork?

Devlin, K. (march 2011). Learning Math with A Video Game. Retrieved from: http://www.maa.org/external_archive/devlin/devlin_03_11.html

Video Games: a Perfect Media for Learning 'Mathematics'

Devlin's approach:

"How to rethink mathematics instruction to take advantage of the opportunities for enhanced mathematics learning that video games provide."

(Devlin, p. ix)

Mathematical Thinking

"But **to confuse mathematical thinking with mastery of basic skills** is akin to confusing architecture with bricklaying, or playing a musical instrument with being able to play the musical scale.

You can't think mathematically if you have not mastered the basic skills. But mathematical thinking is far more than merely having the basic skills at your fingertips, just as architecture is more than laying bricks and music more than playing notes."

(Devlin, 2011, p.2)

Mathematical Thinking & Basic Skills

"[Basic skill mastery] is indeed required for [developing mathematical thinking], but the skills are much more easily acquired when encountered as a part of mathematical thinking."

(Devlin, 2011. p.2)

"Mathematics, something you *do*"

"[M]athematics is not about acquiring basic skills or learning formulas. It's a way of thinking about problems in the world. The skills are merely the tools you need in order to do that thinking.

Math is not a body of knowledge, it's something you *do*.

The best way for an individual to learn how to do something is, as the Nike slogan says, "Just do it!"

(Devlin, 2011, p.2)

‘Mathematics Simulator’

“Airlines train their pilots to fly aircraft not by putting them in control of a real airplane but by giving them time in a flight simulator.

NASA trains its astronauts the same way.

Medical schools now train surgeons using simulation…

This is the way we should be teaching middle-school mathematics…

With video game technology, you can do it.”

(Devlin, 2011, p.3)

Math Making Sense in the Video Game Context

One significant contribution the video game makes is…[that] it gives the mathematics meaning by embedding it in a real context – albeit where that "real context" is within a virtual world and does not have to resemble anything in the real world we live in.

When the students first encounter the abstract, symbolic mathematics – most likely in class – they have had an *experience* that provides meaning for those symbols, and they are motivated to master the material.

(Devlin, 2011, p. 175)

Using Video Games in Virtual Worlds

- The immersive environment of a video game is an ideal one in which to learn everyday mathematics (and which can be designed to provide many examples of everyday math)
- The game can provide structure to the learning
- The game can provide the incentive for the player to keep playing – and in so doing to keep learning
- Both the environment and the game can be pleasurable and stimulating, two important prerequisites for good learning.

Epistemic Video Games

The game is no longer about learning how to do math; it is about learning how to be a (better) mathematician. (Devlin, 2011, p. 126)

Offenholly (2011) describes an epistemic mathematical computer game as one in which "[t]he player becomes a mathematician and problem solver within the context of the game" (p. 45).

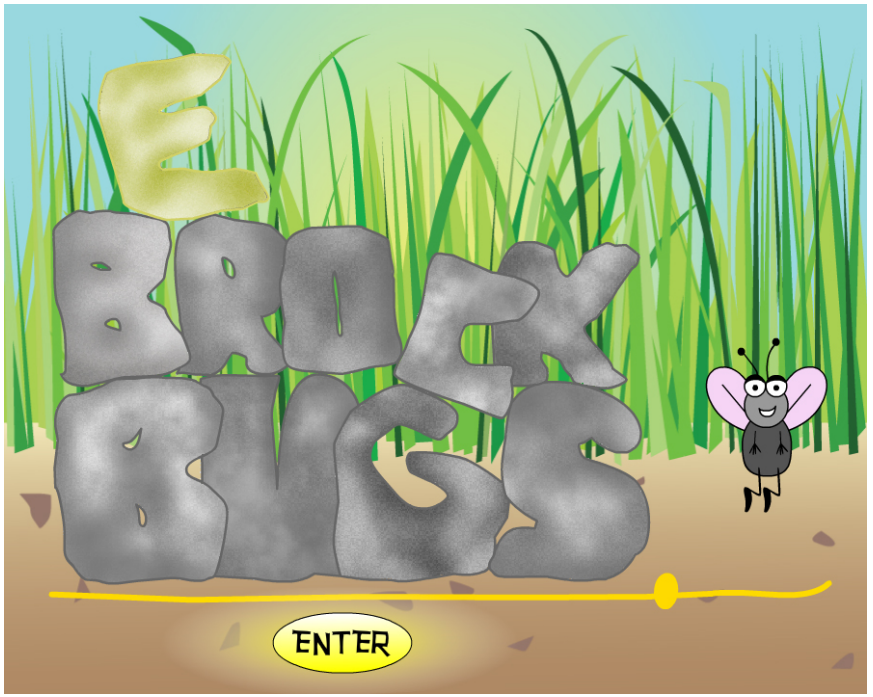
In such a game, Devlin argues that, "[t]hinking mathematically should simply be part of what the character does in that world." (p.127)

Offenholley, K. (2011). Toward an analysis of video games for mathematics education. *Journal of Mathematics Education at Teachers College, 2*, 45-48.

E-Brock Bugs©
Free Math Computer Game

created by Laura Broley
(as her MICA Honours project)
with Chantal Buteau & Eric Muller

- designed using principles of an epistemic math computer game (Devlin, 2011).
- based on **Brock Bugs** board game (Muller, 1999) - *recommended by O.A.M.E. as additional resource for MDM4U course (unit 1)*



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Broley, L. (2013). E-Brock Bugs: The Creation and Analysis of an Epistemic Mathematics Computer Game. Unpublished Honour's Thesis, Brock University, St.Catharines (Canada).

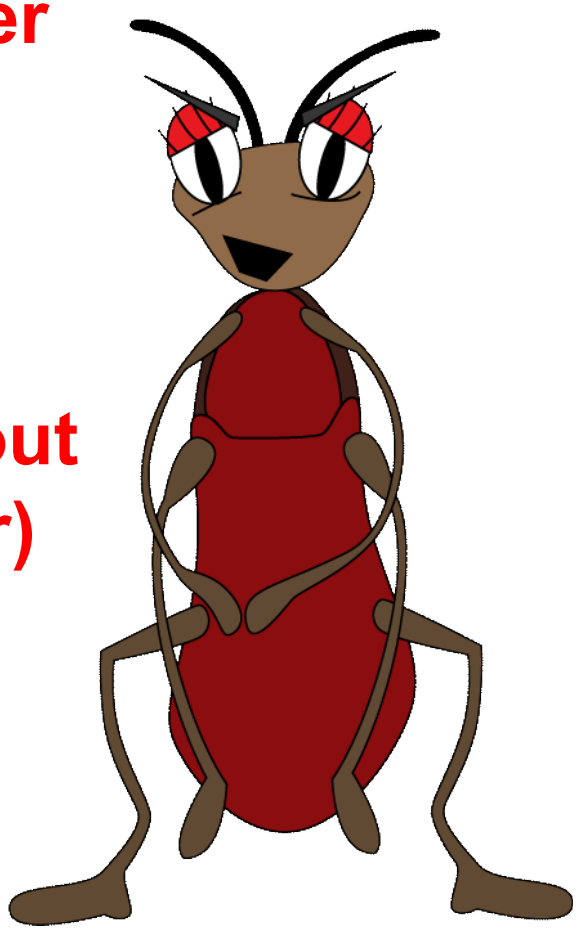
“the back story is crucial to the success of the game”

(Devlin, 2011, p. 134)

…by selecting a character, **the player easily identifies with the character and therefore wants this character to succeed.**

The game is no longer about learning how to do math; it is about learning how to become a (better) mathematician.

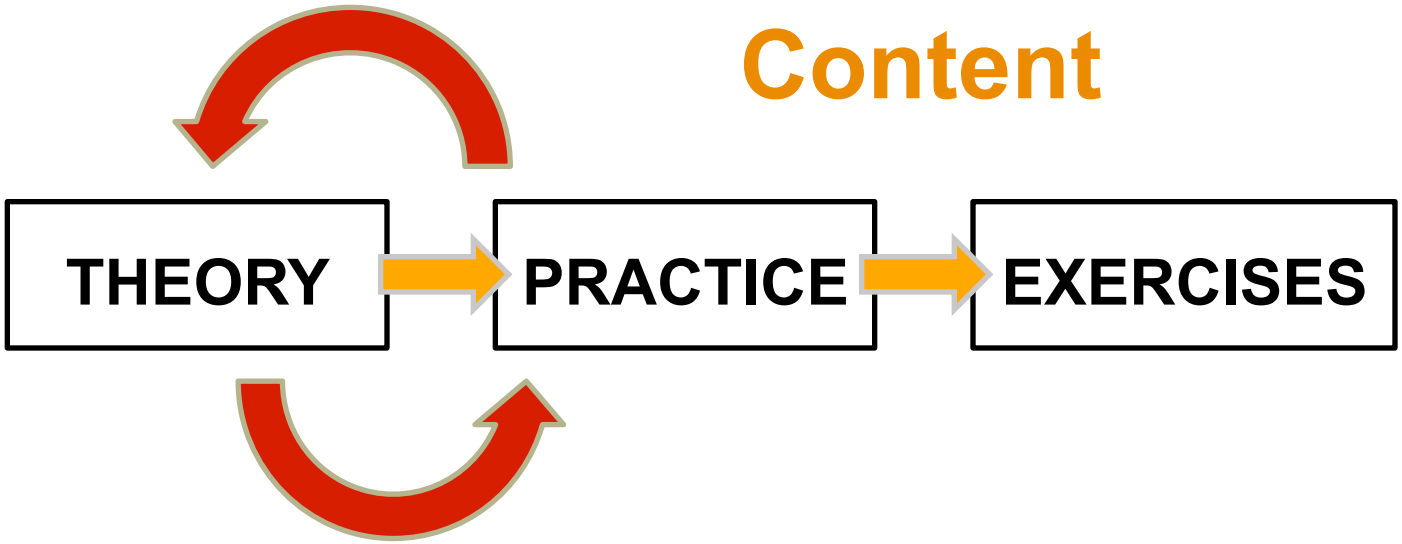
(Devlin, 2011, p. 126)



To get players to adopt this mathematical identity, **"math should arise naturally in the game, it should have meaning in the game, and it should make sense in the game."**

(Devlin, 2011, p. 127)

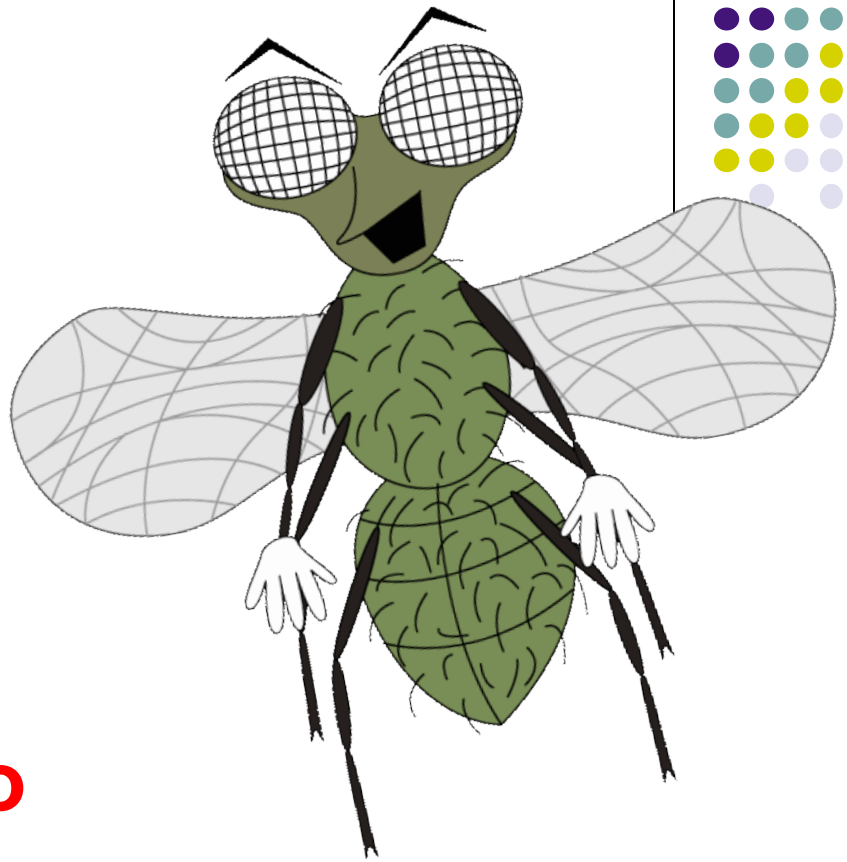
Traditional Presentation of Content

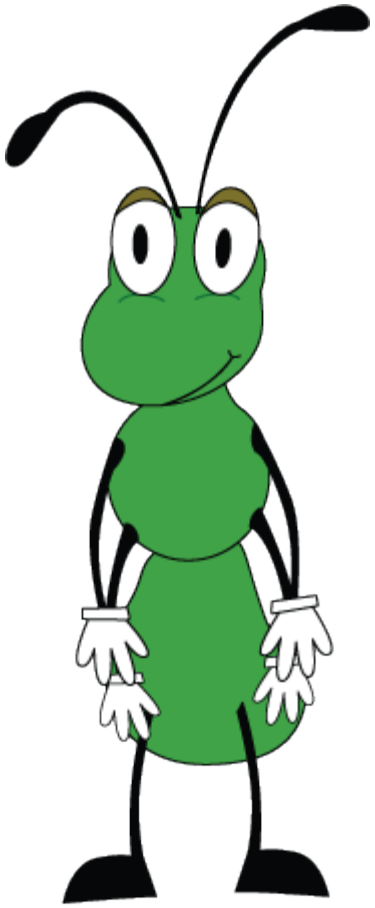


E-Brock Bugs Presentation of Content

“There should be **sufficient 'cost' at getting something wrong to motivate correction, but not so great that it leads to the student losing heart and giving up**.”

(Devlin, 2011, p. 30)



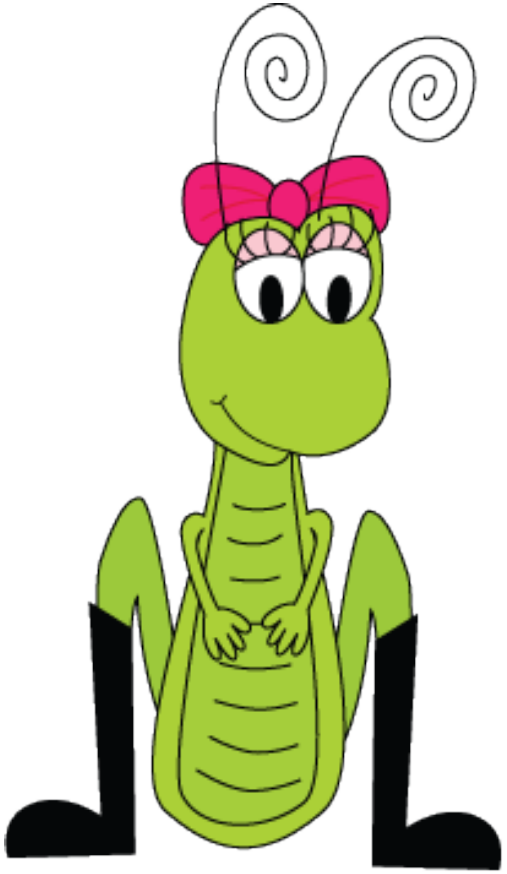


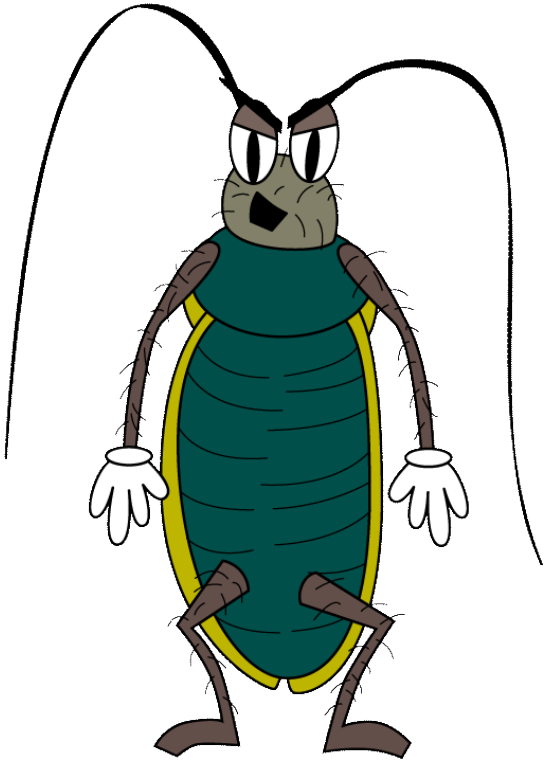
"while conceptual understanding is a goal that educators should definitely strive for, we need to accept that it cannot be guaranteed, and accordingly **we should allow for the learner to make progress without fully understanding the concepts**."

(Devlin, 2011, p. 115)

the mathematical knowledge should be given "both on-demand and just-in-time, when the learner needs it or just at the point where the information can best be understood and used in practice."

(Devlin, 2011, p. 99)





"The environment should store and present the students with **pre-planned learning experiences, some of them in a particular order.**"

(Devlin, 2011, p. 29)

The Math in E-Brock Bugs

Common Threads throughout the Game:

- frequency and relative frequency bar graphs
- $\dfrac{\text{frequency}}{\text{total possibilities}}$
- empirical versus theoretical probability

The Math in E-Brock Bugs

increased difficulty and engagement

requires pencil and paper

(1) Sum of Two Dice:
probability distribution + addition rule

(2) Sum of Two Fibonacci Dice:
asymmetric probability distribution

(3) Sum of Two Drawn Balls: independent/ dependent events + product rule

(4) Sum of Two Spinners:
equally/not equally likely events

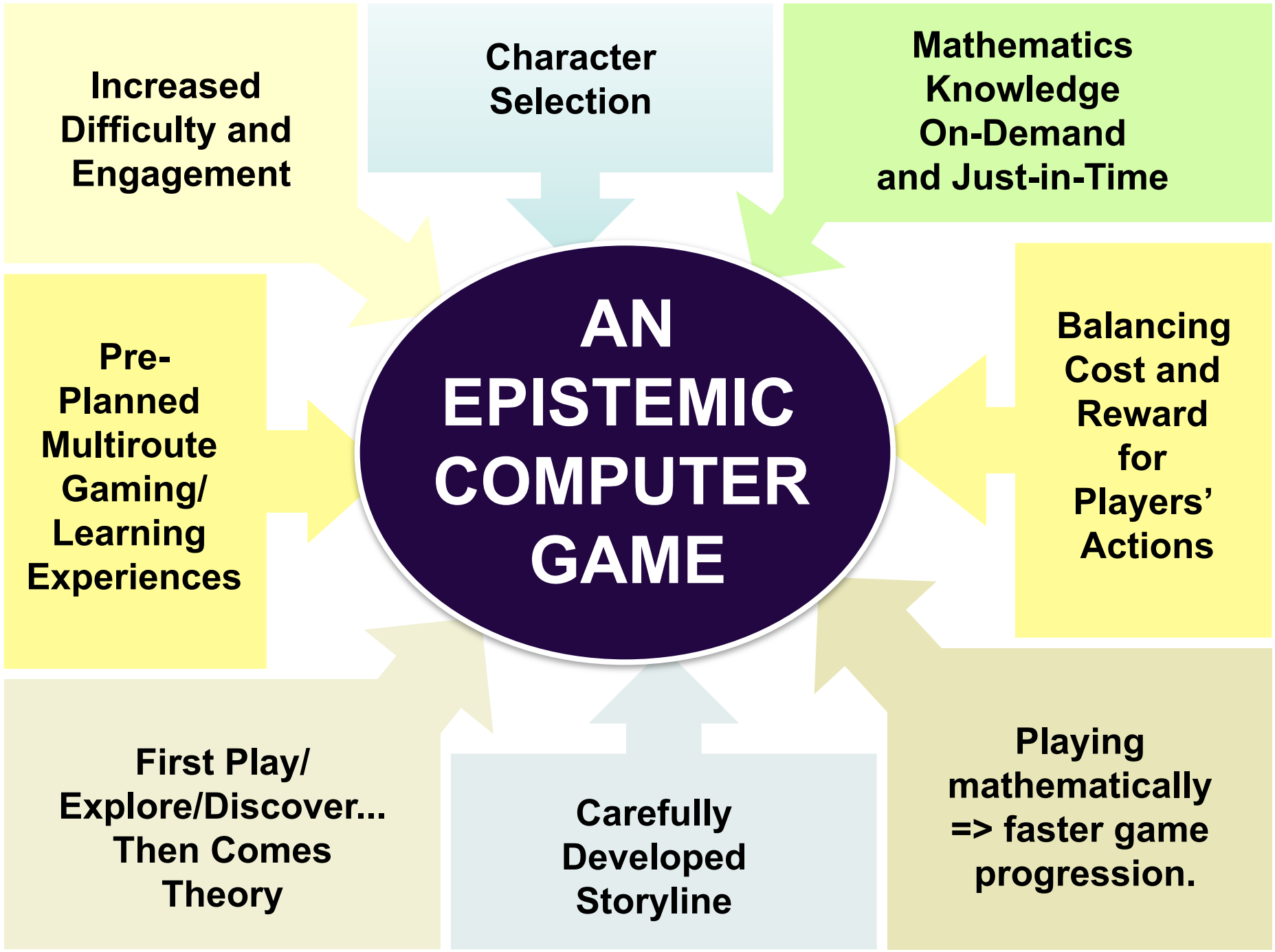
$$\frac{\text{frequency}}{\text{total possibilities}}$$

(5) Number of Seven Bi-Spinners:
Binomial distribution

(6) Sum of Two Dice with Point Values:
expected value

(?) The Finale:
Binomial distribution

randomized distributions

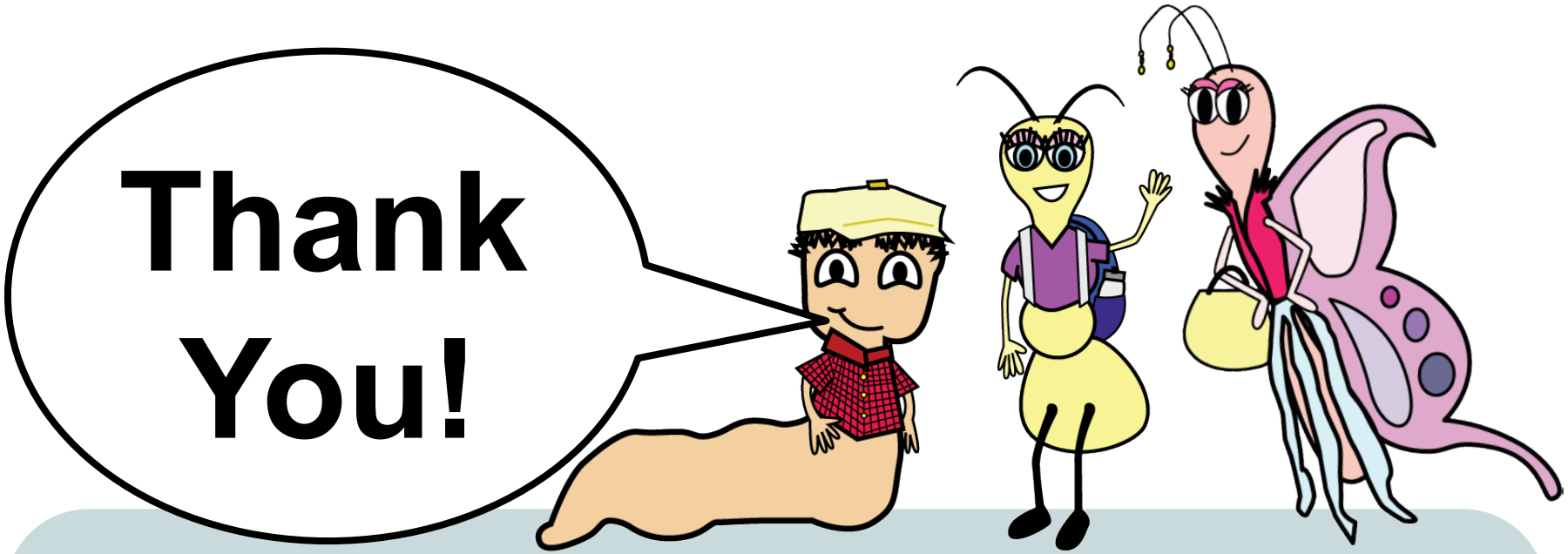

Increased Difficulty and Engagement
Character Selection
Mathematics Knowledge On-Demand and Just-in-Time
Pre-Planned Multiroute Gaming/ Learning Experiences
AN EPISTEMIC COMPUTER GAME
Balancing Cost and Reward for Players' Actions
First Play/ Explore/Discover... Then Comes Theory
Carefully Developed Storyline
Playing mathematically => faster game progression.

Important Extras

E-Brock Bugs Online Hall of Fame proudly lists all the heroes who have saved Bug City… ***Be part of it!***
http://tinyurl.com/HallOfFame-e-brock-bugs

E-Brock Bugs Teacher Document provides an overview of the didactical aim of the game:
www.brocku.ca/mathematics/brock-bugs

Together with E-Brock Bugs 'Unlocked Teacher Version'



E-Brock Bugs Computer Game

www.brocku.ca/mathematics/e-brock-bugs-game