*

The Future of Computers in Education

28 May, 2009

Dr. Stefan Brandle
Visiting Fulbright Scholar
University of Mauritius

* http://www.school-clipart.com

Challenges in Speaking About Education (1)

- There is an Internet joke about the Oxford University Entrance Exam. Verbatim excerpts follow:
  - B I O L O G Y

    Create life.

    Estimate the differences in subsequent human culture if this form of life had developed 500 million years earlier, with special attention to its probable effect on the English parliamentary system.

    Prove your thesis.

www.sucs.swan.ac.uk/~cmckenna/humour/education/oxford.html

Challenges in Speaking About Education (2)

- S O C I O L O G Y
  - Estimate the sociological problems which might accompany the end of the world.
  - Construct an experiment to test your theory.
- P H Y S I C S
  - Explain the nature of matter.
  - Include in your answer an evaluation of the impact of the development of mathematics on science.

www.sucs.swan.ac.uk/~cmckenna/humour/education/oxford.html

Challenges in Speaking About Education (3)

- Education is a vast and complex subject – like the Oxford University entrance exam
- Education experts do not agree on many issues
- And I am not an expert in education …
- My purpose
  - Dream some with you
  - Share ideas I have been introduced to
  - Hope some ideas will be useful to you

My Five Questions

- Will computers be the teachers of the future?
- Does using computers result in better learning?
- Should we be spending more or less money for computer technology in education?
- What is constructivist learning and how are computers relevant?
- Do computers enable mastery learning?

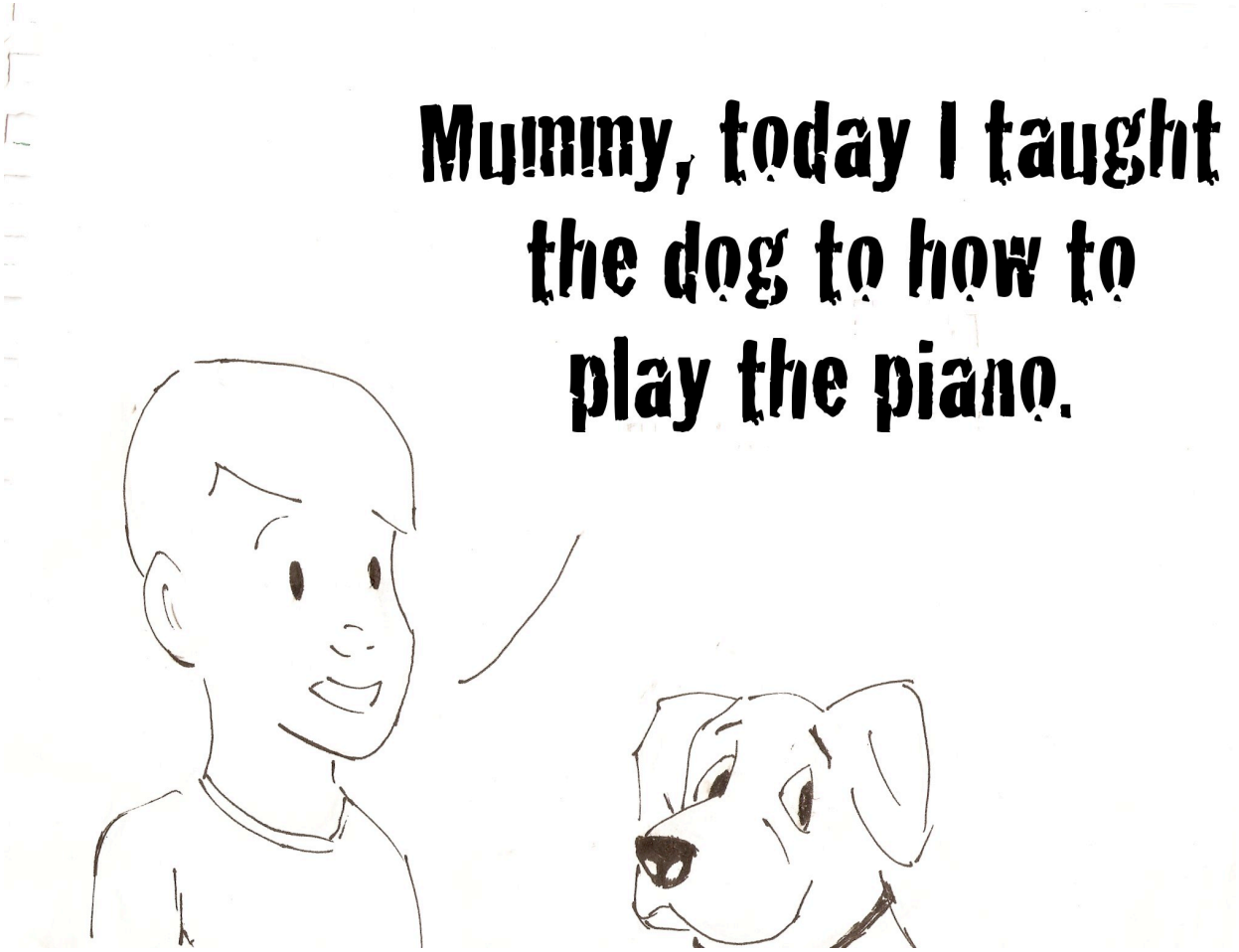
Dreaming About Education

- What will the ideal education be like?
- Philosophers, educators, and science fiction writers have ideas
- Many different answers
  - Nostalgic, no technology: teacher and student sit on a log talking
  - Use technology
  - Science Fiction: Computer teaches
- Who is correct?

So Who Is Correct?

- Will not try to answer that
- Instead, a very quick story

A Quick Story About Education

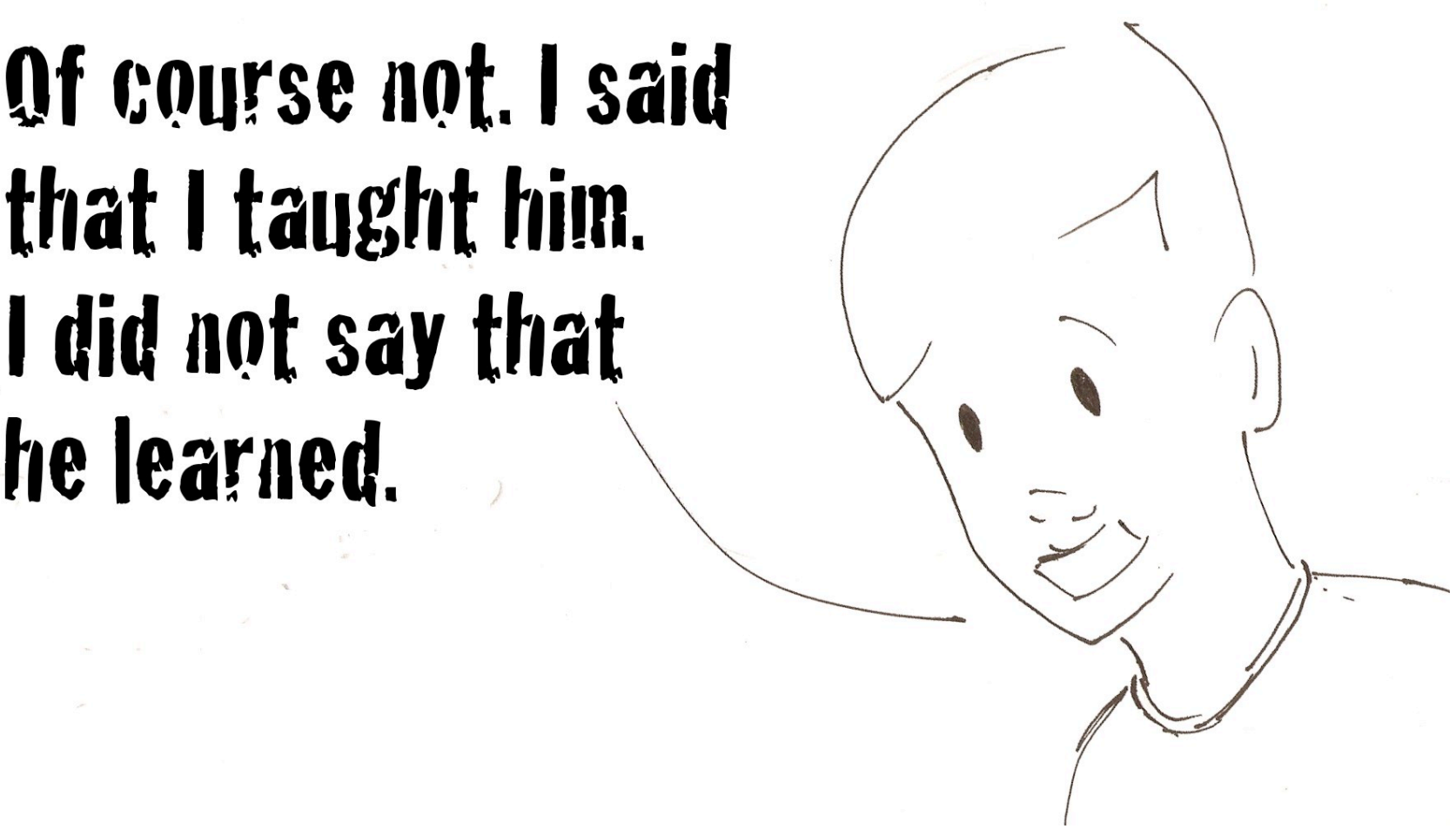


Recreation of a cartoon I read once, but cannot find now. Drawings by Elise Kuick

Impressive Results …

Recreation of a cartoon I read once, but cannot find now. Drawings by Elise Kuick

The Actual Outcome



Recreation of a cartoon I read once, but cannot find now. Drawings by Elise Kuick

Constructivism

- "Constructivist learning theory says that
  - All knowledge is constructed from a base of prior knowledge
  - Children are not a blank slate
  - Knowledge cannot be imparted without the child making sense of it according to his or her current conceptions
  - Therefore children learn best when they are allowed to construct a personal understanding based on experiencing things and reflecting on those experiences."

http://en.wikipedia.org/wiki/Constructivist_teaching_methods

Constructivism

- "One of the primary goals of using constructivist teaching is
  - that students learn how to learn by giving them the training to take initiative for their own learning experiences.
- Characteristics of a constructivist classroom are as follows:
  - the learners are actively involved
  - the environment is democratic
  - the activities are interactive and student-centered
  - the teacher facilitates a process of learning in which students are encouraged to be responsible and autonomous"

http://en.wikipedia.org/wiki/Constructivist_teaching_methods

Elements of an Ideal Education

- Each student
  - Learns at his/her own pace
  - Has available as much help as needed, when needed
  - Is able to determine whether his/her understanding is correct
  - Is allowed to follow interests
  - Achieves an appropriate level of mastery
  - Is able to apply the learning to other problems (transference)

No more theory

- For now …

Examples of Computer-Based Learning

- Basic skills learning (only a mention today)
  - Reader Rabbit: teaches elementary reading & maths
  - Scratch: teaches children how to program by writing multimedia stories
  - Many others exist
- Automated marking and feedback
  - COW: mathematics
  - Maple TA: mathematics
  - Web-CAT: computer programming
- Complex learning environment
  - SimCity Societies: social science/urban planning simulation

Example Application: COW

- COW: Calculus On the Web
- "COW is an internet utility for learning and practicing calculus."
- Currently supports precalculus, calculus, linear algebra, number theory, and abstract algebra

http://cow.math.temple.edu/~cow/cgi-bin/tourguide

Example Application: COW

- “The principal purpose of COW is to provide you, the student or interested user, with the opportunity to learn and practice problems in calculus […] in a friendly environment via the internet.”
- “The most important feature of the COW is that you get to know whether your answer is correct almost immediately. It is as if you had a tutor looking over your shoulder and helping you along as you work.”

http://cow.math.temple.edu/~cow/cgi-bin/tourguide

Slope of the Line Passing Through Two Points

by

David Hartenstine, Matthias Beck and Molly M. Cow

In this module you can practice computing the slope of the line passing through two given points.

Hints about writing your answer...

1) Find the slope of the line passing through the points

$(x_1,y_1) = (3, 0)$ and $(x_2,y_2) = (0, 3)$.

First, find the y-coordinate difference

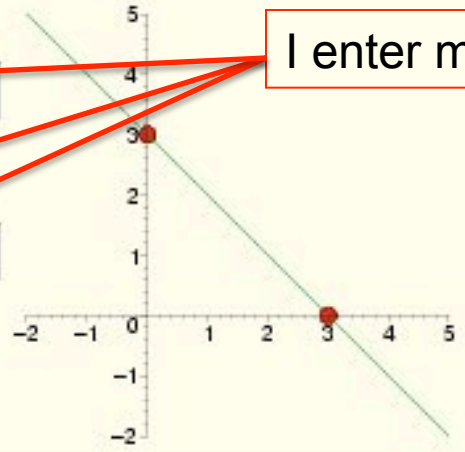
$\triangle y = y_2 - y_1 =$ 3

And the x-coordinate difference

$\triangle x = x_2 - x_1 =$ 3

Now compute the slope.

slope = 3/3



I enter my answers

Check your answer | Next Problem | Previous Problem | Go to: 2 | Help

Typing problems? Expression Interpreter may help.

http://cow.temple.edu/~cow/cgi-bin/manager

Slope of the Line Passing Through Two Points

I'm lost ... Are you lost too?

System response.
Highlighting is my addition
to improve visibility.

Your answer for △ x has the wrong sign, you must have reversed the points.
You were right to calculate the slope as △ y/△ x, but since this data was inaccurate, your answer should be recalculated.

1) Find the slope of the line passing through the points

$(x_1,y_1) = (3, 0)$ and $(x_2,y_2) = (0, 3)$.

First, find the y-coordinate difference

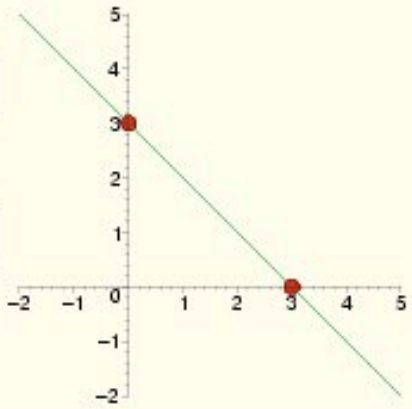
$\triangle y = y_2 - y_1 =$ 3

And the x-coordinate difference

$\triangle x = x_2 - x_1 =$ 3

Now compute the slope.

slope = 3/3



Check your answer | Next Problem | Previous Problem | Go to: 2 | Help

Expression Interpreter

http://cow.temple.edu/~cow/cgi-bin/manager

Slope of the Line Passing Through Two Points

I'm lost ... Are you lost too?

Your answer for △ x has the wrong sign, you must have reversed the points.
You were right to calculate the slope as △ y/△ x, but since this data was inaccurate, your answer should be recalculated.

---

1) Find the slope of the line passing through the points

$(x_1, y_1) = (3, 0)$ and $(x_2, y_2) = (0, 3)$.

I fix my answers

First, find the y-coordinate difference

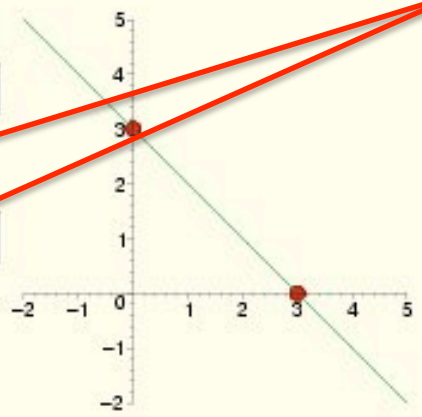
$\triangle y = y_2 - y_1 =$ 3

And the x-coordinate difference

$\triangle x = x_2 - x_1 =$ -3

Now compute the slope.

slope = -3/3



Check your answer | Next Problem | Previous Problem | Go to: 2 | Help

Expression Interpreter

http://cow.temple.edu/~cow/cgi-bin/manager

Success!

Slope of the Line Passing Through Two Points

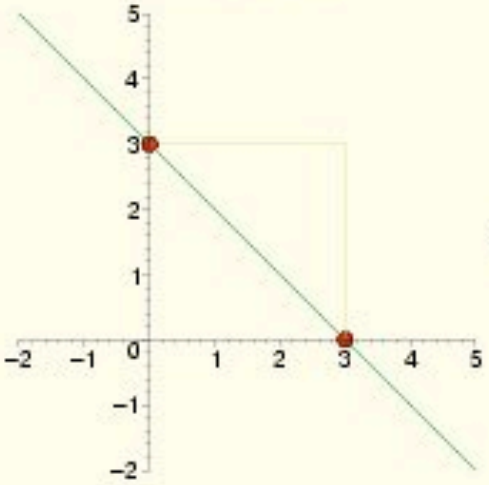
COW Ex: p.4

Good work, Ace.

I have the correct answer. Now for the next problem …

The slope of the line passing through the points (3, 0) and (0, 3) is -3/3.

△ x = -3



△ y = 3

<< Home
<< Books
<< Chapters
<< Sections
<< Modules

Next Problem | Previous Problem | Go to: 2

Expression Interpreter

http://cow.temple.edu/~cow/cgi-bin/manager

Maple T.A.™ 4.0

Online Testing and Assessment ... Powered by Maple™

Maple T.A. is an easy-to-use web-based system for creating tests and assignments, automatically assessing student responses and performance. It supports complex, free-form entry of mathematical equations and intelligent evaluation of responses, making it ideal for mathematics, science, or any course that requires mathematics.

ANYTIME • ANYWHERE

http://www.maplesoft.com/products/mapleta/

Maple T.A. 4.0

- Key Features
- What's New in Maple T.A. 4.0
- View Demo Movie

- Maple T.A., your first choice in assessment technology
  - **When you want to create your own content.** Maple T.A. has the easiest and most comprehensive content authoring tools available
  - **When you are teaching science, math or engineering.** Maple T.A. is the only system designed specifically for technical courses involving mathematics
  - **When you want confidence in your assessment technology.** Maple T.A. is developed by Maplesoft, a trusted name in education technology with years of experience developing products for technical academics

- Maple T.A. makes online testing and assessment easy and cost effective

Maple T.A. lets you offer tests anywhere, anytime. It does the marking for you, and makes it simple to analyze the results.

- The power of Maple brings you the richest, most comprehensive system available for mathematics assessment!

Open-ended free-response questions, 2-D and 3-D plots, and built-in mathematics and randomization tools are just some of the benefits of having Maple built-in.

Web-CAT

- "Web-CAT is a plug-in-based web application that supports electronic submission and automated grading of programming assignments."
- Developed at Virginia Tech University
- My Fulbright Project was enhancing and introducing Web-CAT at the University of Mauritius
- U of M Department of Computer Science and Engineering is using Web-CAT
  - Used by 347 distinct students since March, 2009

http://web-cat.cs.vt.edu/

Quick History of Automated Marking of Student Programs

- *Earliest I have found*: J. Hollingsworth, "Automatic Graders for Programming Classes", Communications of the ACM, October, 1960. Used punch cards.
- Papers I have found
  - 1960-1970: 3 papers
  - 1970-1980: 1 paper
  - 1980-1990: 11 papers
  - 1990-2000: 28 papers
  - 2000-present: 41+ papers
- A number of automated program marking systems are currently in use

Time: A Reason to Automate Marking

- Assume 100 students in the class; 1 marked assignment every two weeks; 5 minutes to process each assignment
- 100 students/assignment * 5 minutes/student = 8.3 hours/assignment (~1 day)
- 8.3 hours/assignment * 7 assignments/semester = 14.5 working days/year
- **NOTE:**
  - 5 minutes per student is optimistic
  - For **very** simple assignments
  - Limited assessment by teacher
  - Almost no feedback to students

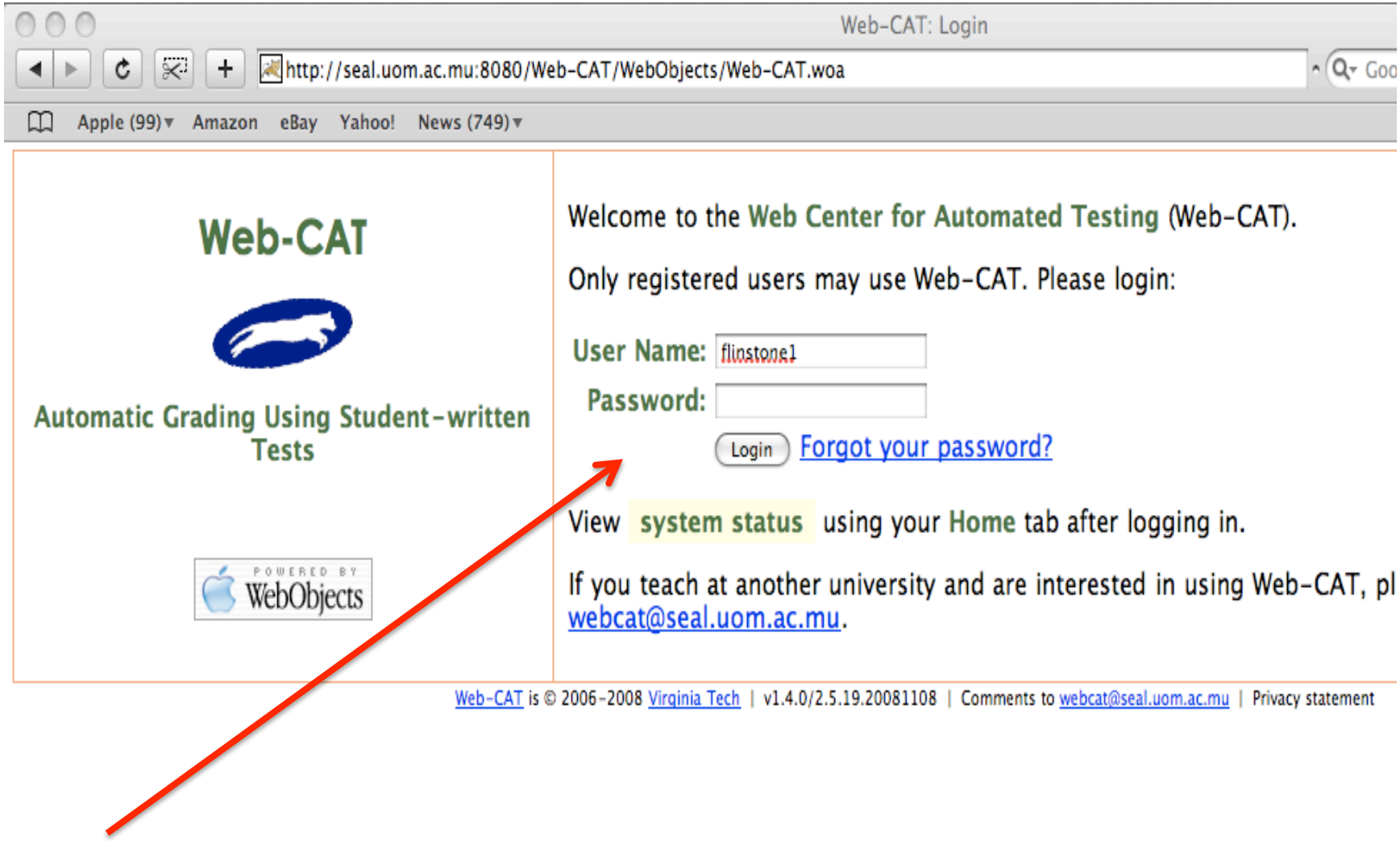
Another Reason to Automate Marking

- Consistent Marking of Assignments
  - Inter-rater and intra-rater reliability is difficult
  - Inter-rater: agreement among different people rating (marking) an artifact (document, program, painting, poem, etc.)
  - Intra-rater: agreement by the one person rating the same or an equivalent artifact at different different points in time

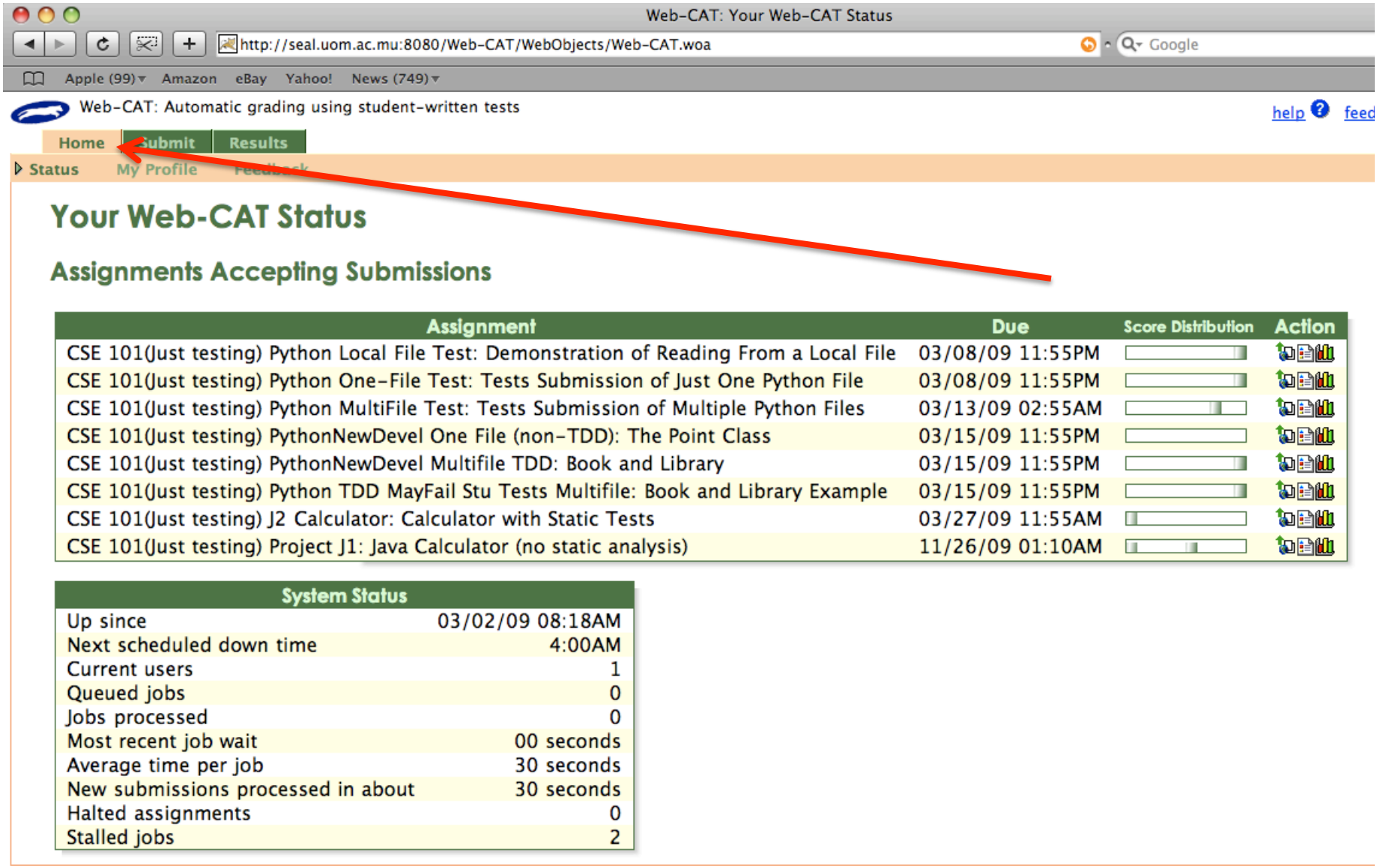
Your Program Is Finally Ready

- Program has been
  - Designed
  - Written
  - Tested
  - It is perfect!
- Submit it to Web-CAT
  - A unit-testing based computer system for marking student assignments
  - Primary development at Virginia Tech University
  - Installed also on the server “seal” at the University of Mauritius
- Go to “http://seal.uom.ac.mu:8080/Web-CAT”

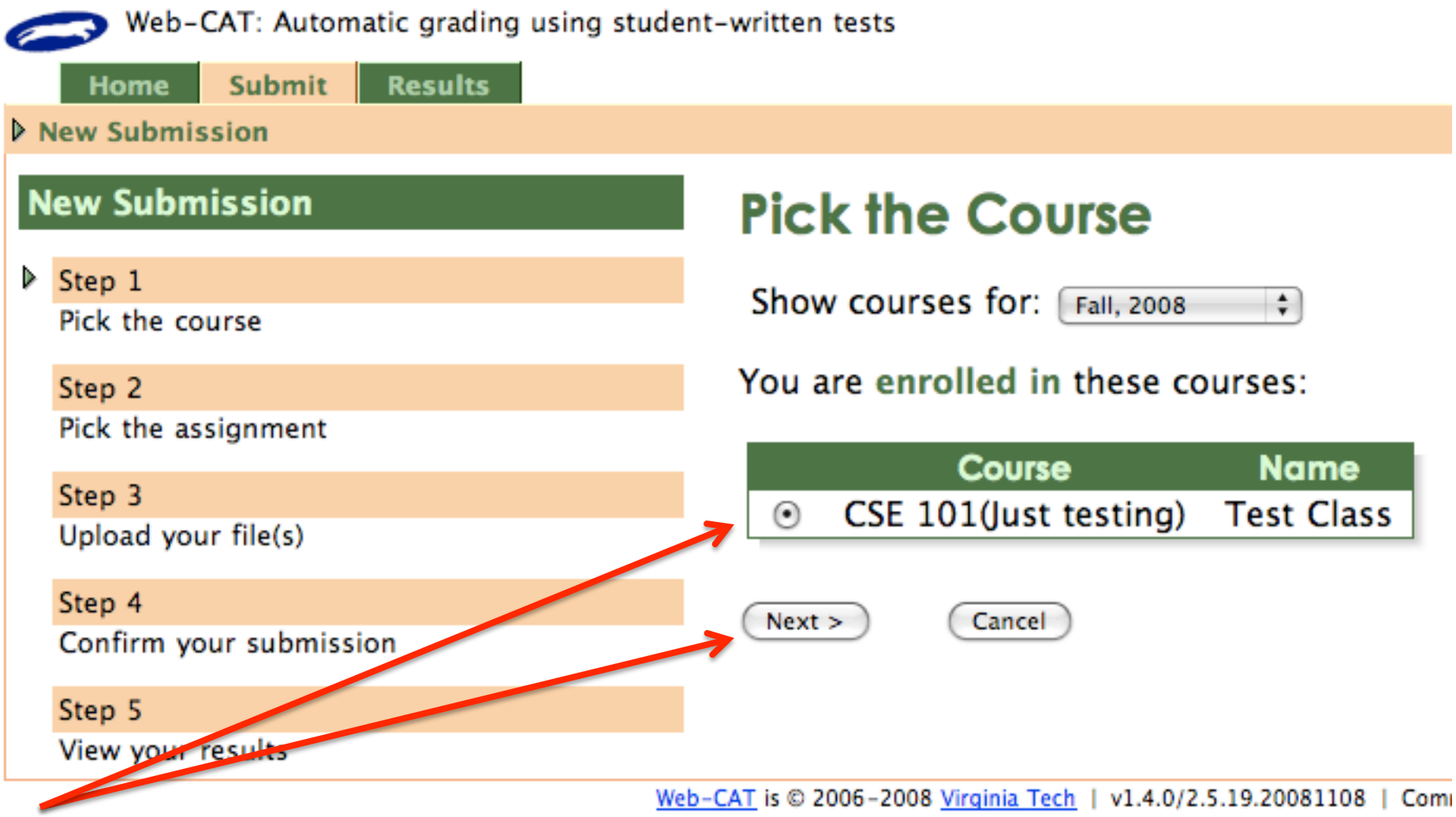
Using Web-CAT: (1) Login



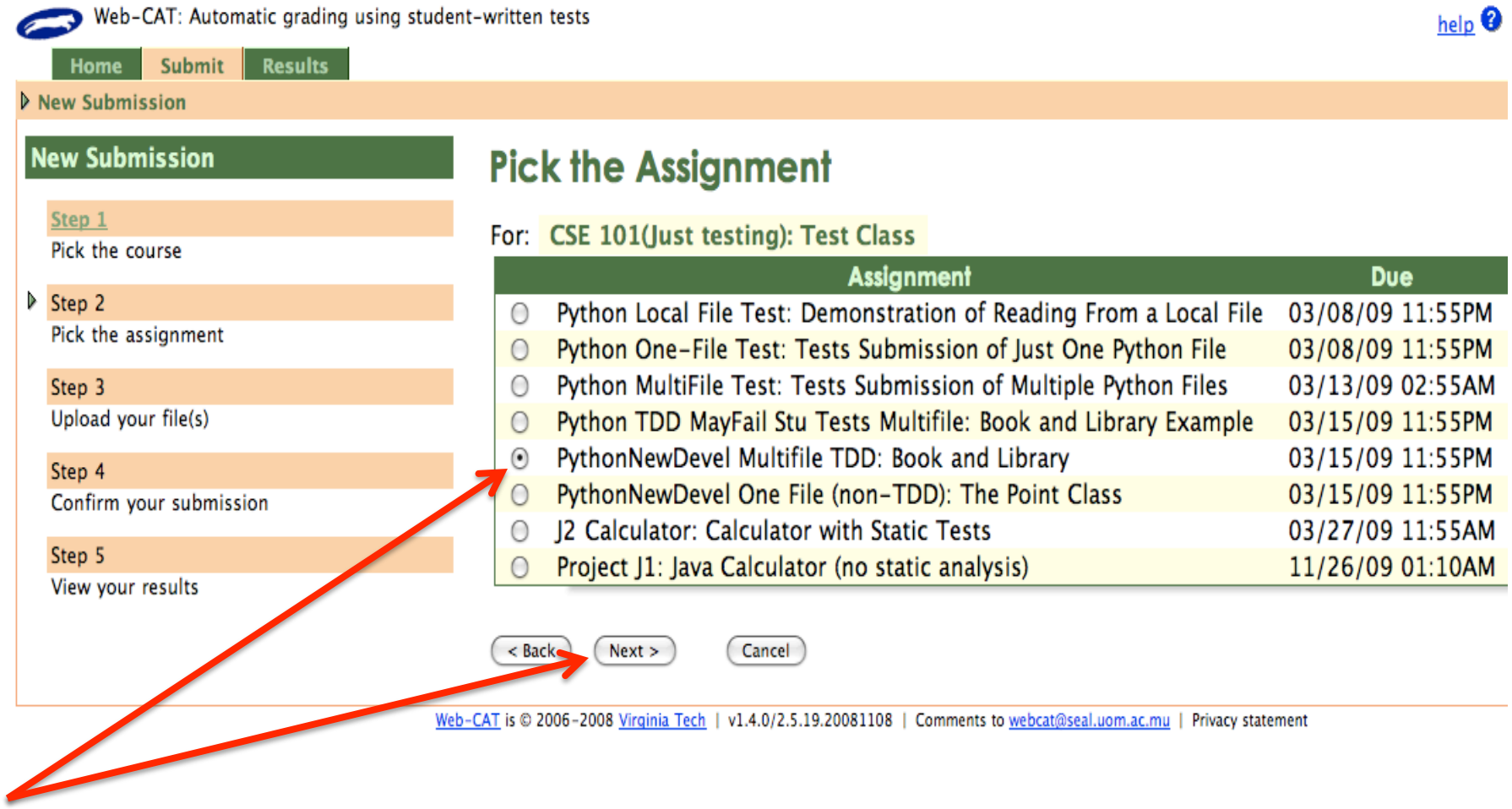
Using Web-CAT: (2) Home Page



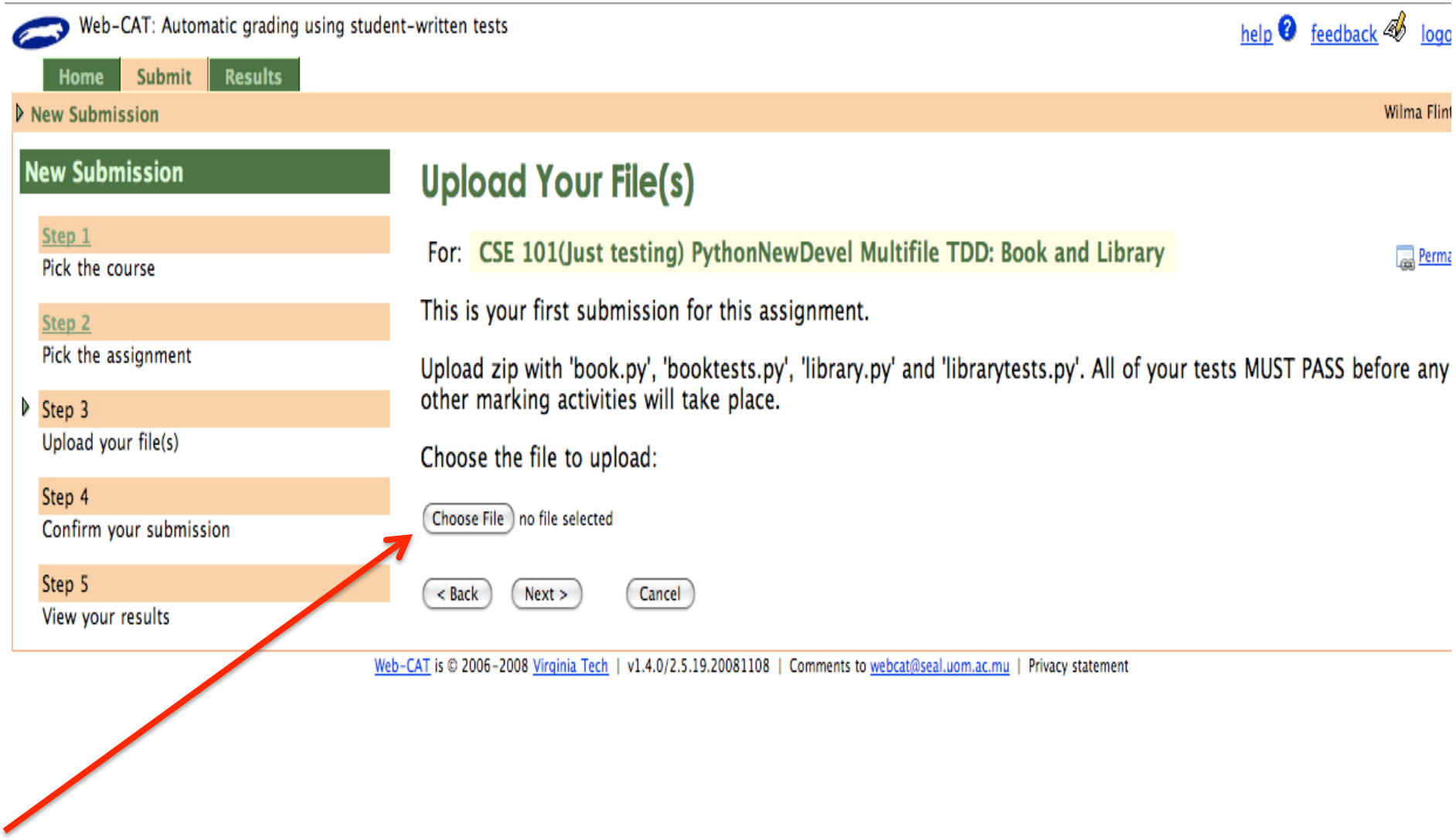
Using Web-CAT: (3) Submit Tab



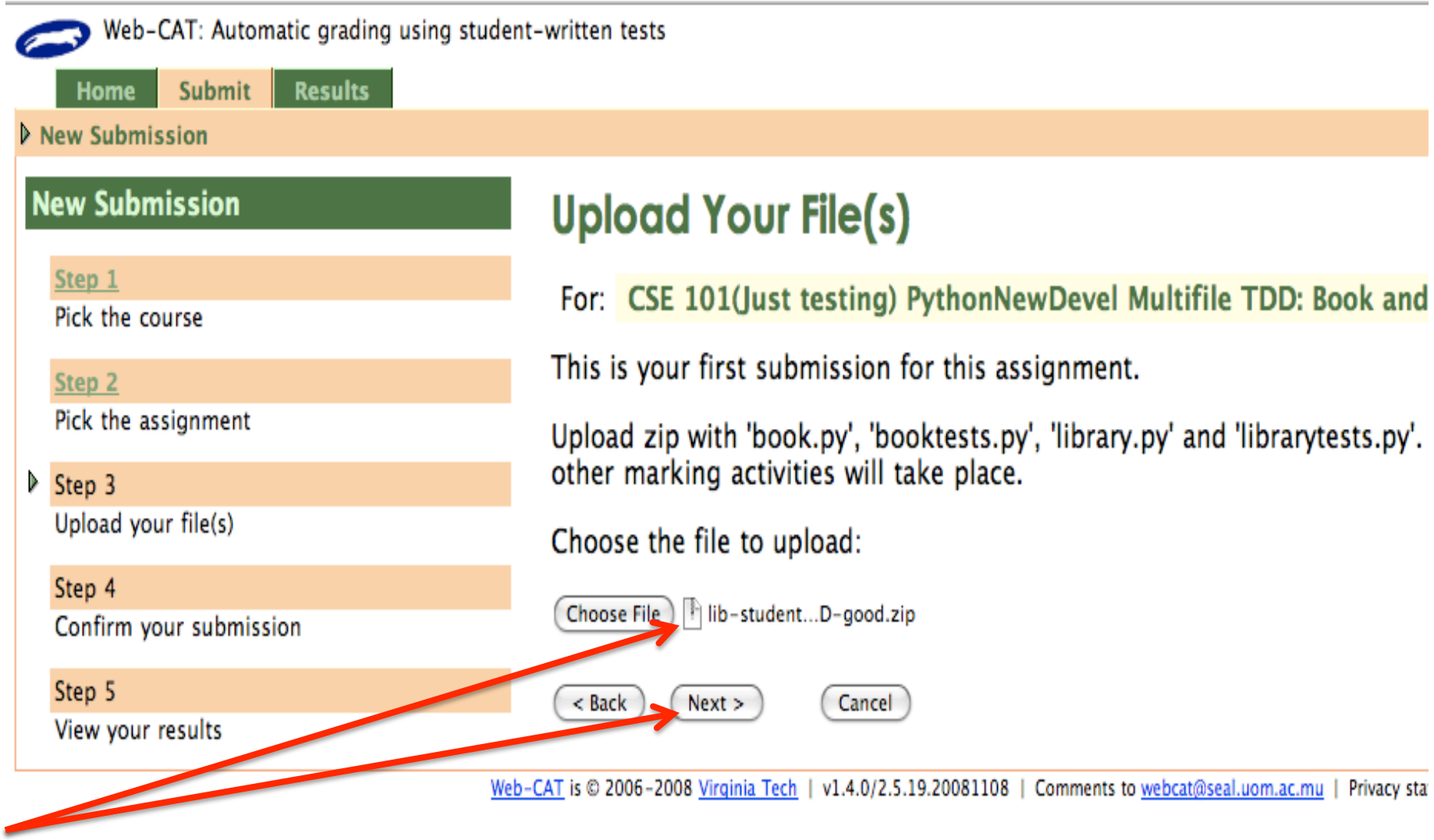
Using Web-CAT: (4) Choose Assignment



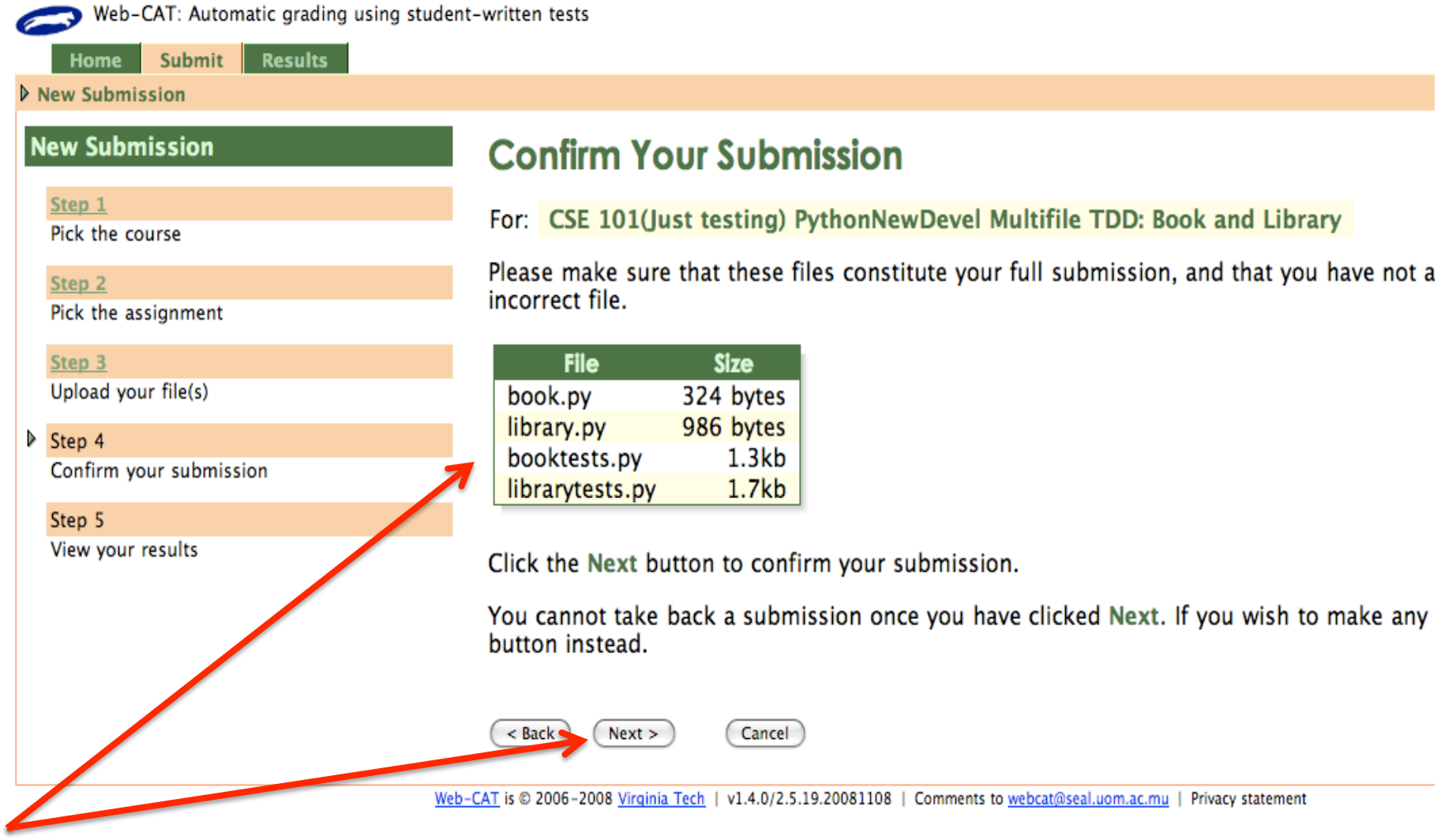
Using Web-CAT: (5) Read Instructions



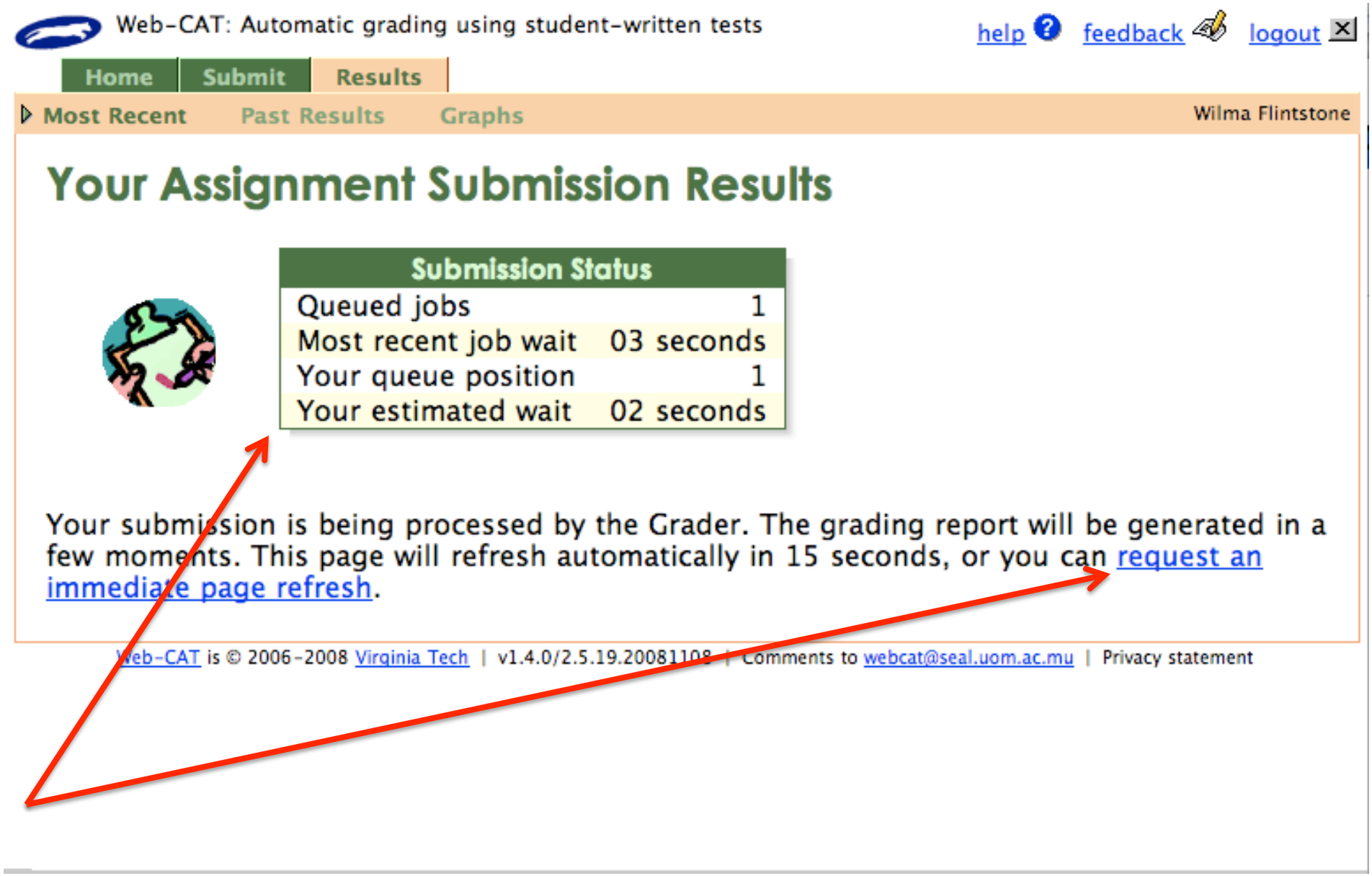
Using Web-CAT: (6) Attach File(s)



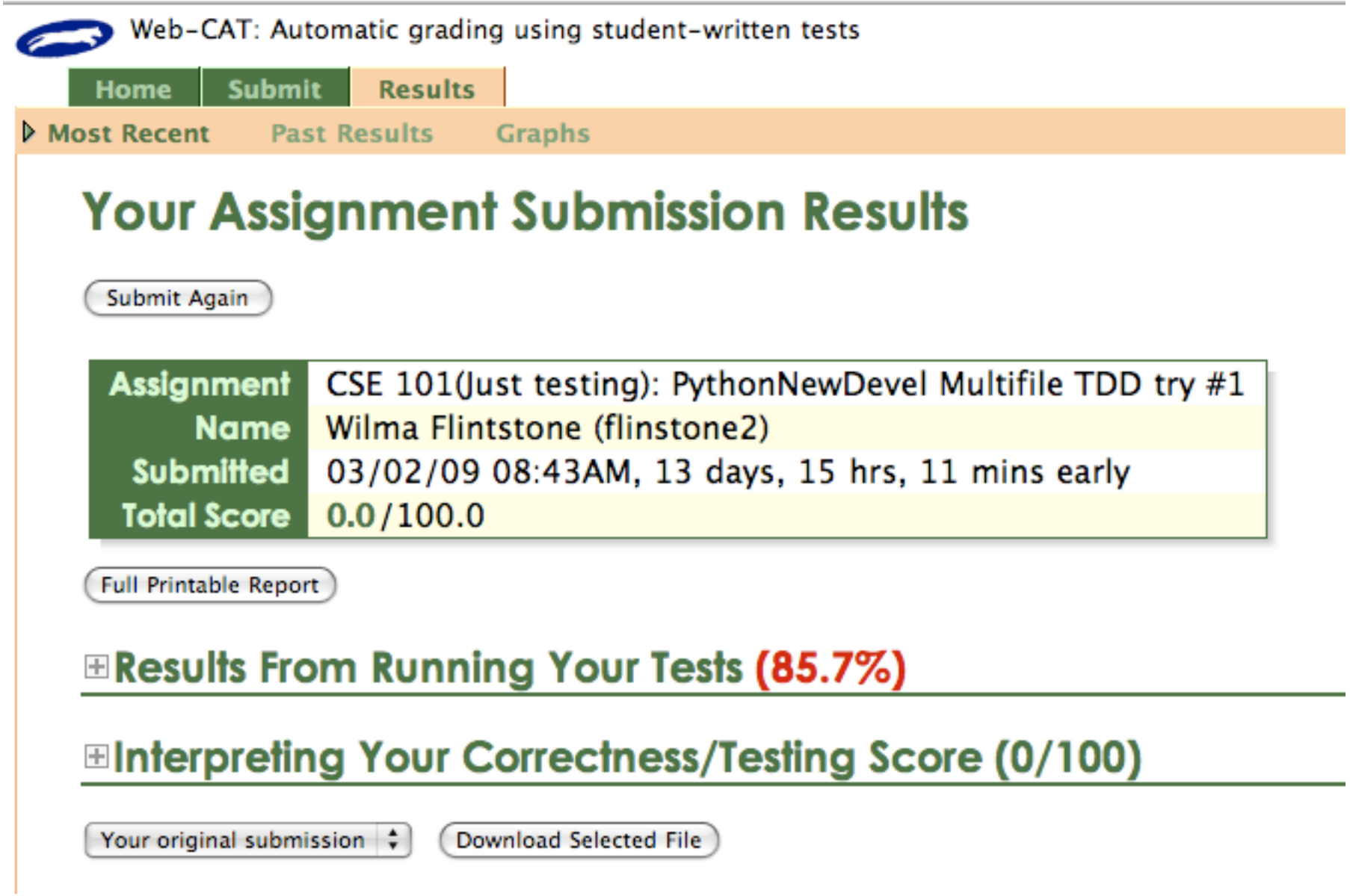
Using Web-CAT: (7) Confirm Submission



Using Web-CAT: (8) Wait for Results



Using Web-CAT: (9) Overview of Results



Using Web-CAT: (10) Examine Details

Assignment	CSE 101(Just testing): PythonNewDevel Multifile TDD try #3
Name	Wilma Flintstone (flinstone2)
Submitted	03/02/09 08:46AM, 13 days, 15 hrs, 8 mins early
Total Score	0.0/100.0

Full Printable Report

Results From Running Your Tests (85.7%)

Summary: 7 cases (1 failure, 0 errors)

```
Testing module 'book'
...
------
Ran 3 tests in 0.000s
OK

Testing module 'library'
.F..
------------------
FAIL: getBook: Test getting an invalid book from library
AssertionError: Book incorrectly found
------
Ran 4 tests in 0.001s
FAILED (failures=1)
```

Interpreting Your Correctness/Testing Score (0/100)

Using Web-CAT: (11) Interpret Score

Submit Again

Permalink

Assignment	CSE 101(Just testing): PythonNewDevel Multifile TDD try #3
Name	Wilma Flintstone (flinstone2)
Submitted	03/02/09 08:46AM, 13 days, 15 hrs, 8 mins early
Total Score	0.0/100.0

Full Printable Report

⊞ Results From Running Your Tests (85.7%)

⊟ Interpreting Your Correctness/Testing Score (0/100)

This assignment requires that all student tests pass before any other results are computed.
Because some of your tests failed, only the results of your testing are shown and your score will be zero until your code passes all your tests.

Results from running your tests:	85.7%
No other tests attempted	0%

score = 85.7% * 0% * 100.0 points possible = 0

Full-precision (unrounded) percentages are used to calculate your score, not the rounded numbers shown above.

Oops! Your code was not quite perfect

- There are a number of possible problems
  - Your code does not pass your own tests (optional marking)
  - Your tests do not test all of your code (optional marking)
  - Your code does not pass the instructor's tests
- The assignment can also be set up to
  - Check your code style
  - Require that your code passes your tests before any other marking is done
- If you did your own testing before submitting and examine your code, a number of these problems can be avoided

Fix, Test, and Resubmit

- Repeat until perfect
  - Examine test results
  - Look at your code
  - Find the errors
  - Fix them
  - Test your code
  - Resubmit

Iteration Does Make Perfect

Your Assignment Submission Results

Submit Again

Permalink

Assignment	CSE 101(Just testing): PythonNewDevel Multifile TDD try #4
Name	Wilma Flintstone (flinstone2)
Submitted	03/02/09 09:02AM, 13 days, 14 hrs, 52 mins early
Total Score	100.0/100.0

Score Summary		
Correctness/Testing:	100.0/100.0	
Final score:	100.0/100.0	

Position in class: Show Graphs

Full Printable Report

⊞Results From Running Your Tests (100%)

⊞Code Coverage from Your Tests (100.0%)

⊞Results From Running Your Instructor's Tests (100%)

⊞Interpreting Your Correctness/Testing Score (100/100)

Benefits of Automated Marking

- Students
  - Have an always available tutor
  - Receive fast, reasonable quality, and consistent feedback
  - Have support to achieve mastery
  - Know at all times how well they are doing
- Teachers
  - More likely to assign the quantity of work that students need
  - Are freed to use their time for individual attention at school
  - Can reallocate much of time spent marking, to lesson preparation and personal learning

Quality of Automated Marking

- Cite three examples
  - RUReady: “Online parsing system that produces partialcredit scoring of students’ constructed responses to mathematical questions”
  - Educational Testing Service: “Comparing The Validity Of Automated And Human Scoring Of Essays”
  - Automatic Essay Assessor: “Move from fully automatic grading towards semi-automatic assessment”

RUReady

- Paper title: “Can Automated Scoring Surpass Hand Grading of Students' Constructed Responses and Error Patterns in Mathematics?”
  - Immediate error analysis for each student response.
  - The parser scoring was validated against human scoring of 207 realworld student responses
  - Software generates more consistent scores than teachers in some cases.
- Overall, the parser’s total scoring closely matched human scoring, but the machine was found to surpass humans in systematically distinguishing between students’ error patterns.

Verbatim quotes from Livne, Livne, and Wright

Educational Testing Service (ETS)

- Paper title: “Comparing The Validity Of Automated And Human Scoring Of Essays”
- “Automated, or computer-based, scoring represents one promising possibility for improving the cost effectiveness (and other features) of complex performance assessments (such as direct tests of writing skill) that require examinees to construct responses rather than select them from a set of multiple choices. Indeed, significant advances have been made in applying natural language processing techniques to the automatic scoring of essays.”
- Overall: Interesting and impressive, but not quite ready.

Powers, Burstein, Chodorow, Fowles, and Kukich (all at ETS)

Automatic Essay Assessor (AEA)

- "While an automatic grading module forms the backbone of any essay assessment system, recent research on automatic assessment has been directed toward more transparent and detailed measures of essay quality. The idea in AEA is to move from fully automatic grading towards semi-automatic assessment."
- "Provides scores for different components of the essay such as the content, the writing style, and the structure of argumentation."
- "Support teachers during the evaluation process"
- "Help students to reflect on their learning process as early as possible and point out the strong and weak aspects of an essay."

Tuomo Kakkonen: http://cs.joensuu.fi/~tkakkone/essay_assessment.html

Automatic Essay Assessor (AEA)

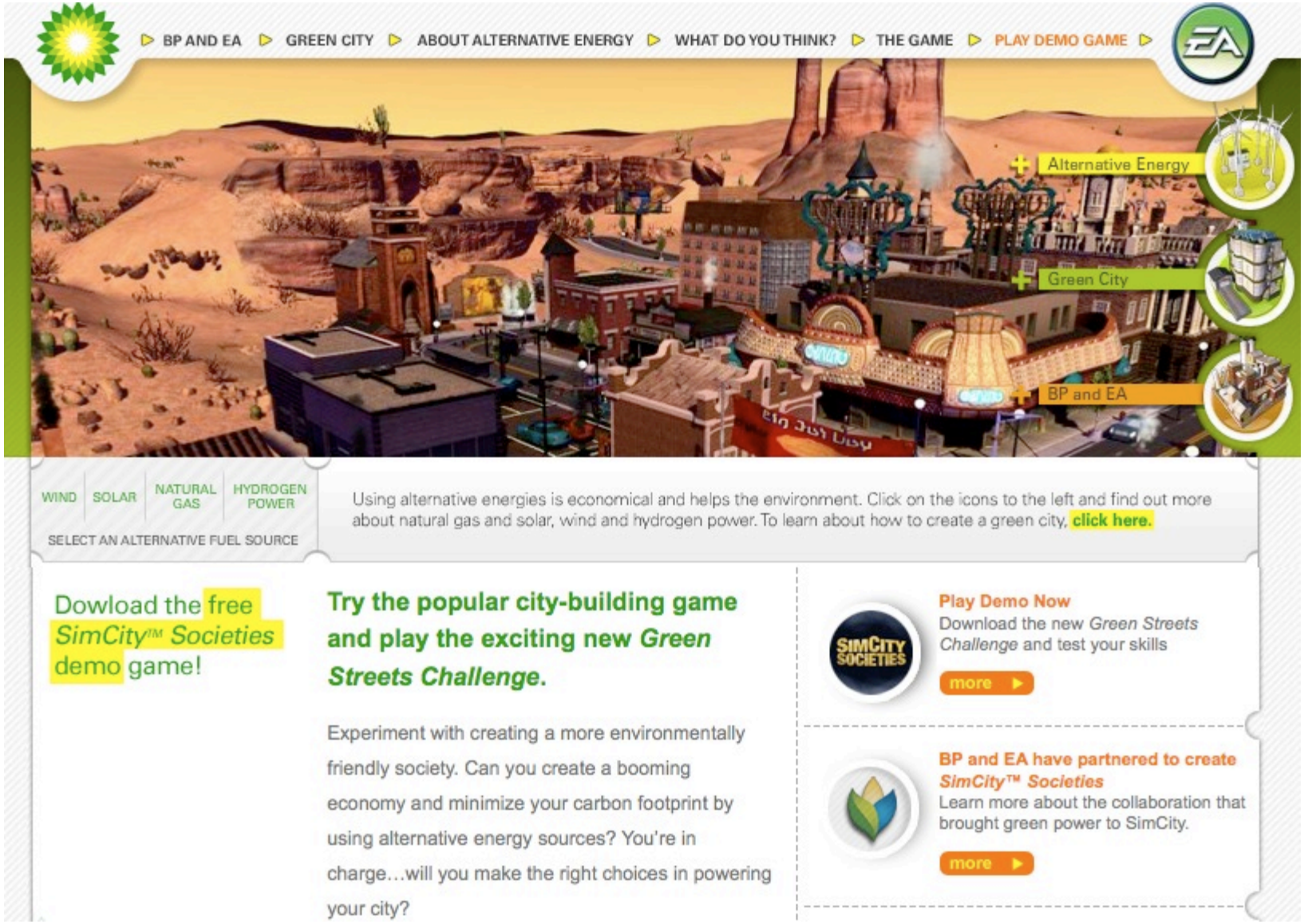
- "NLP techniques, such as automatic summarization, the detection of rhetorical structure and writing style, are applied in state-of-the-art assessment systems."

- "This paradigmatic shift from teacher-centered assessment towards learner-centered process evaluation offers interesting challenges to educational technologists and NLP researchers. We are currently developing following methods that enable semi-automatic assessment:
  - Automatic feedback generation
  - Plagiarism detection
  - Visualization of evaluation results"

Tuomo Kakkonen: http://cs.joensuu.fi/~tkakkone/essay_assessment.html

SimCity Society

SimCity Society + BP = Green Streets



http://bpsimcitysocieties.com

SimCity Society + BP = Green City

http://bpsimcitysocieties.com/simcity-societies-green-city

SimCity Society “Trailer 1”

SimCity 4: Rush Hour Demo

Challenges in Education

- Cost
- Access
- Methods
- Results

- Many more
- Not insurmountable obstacles

Example: Cost of Computers

- One Laptop Per Child ($200)
  - laptop.org/en
- Amazon Kindle 2 (US $350)
  - http://www.amazon.com/Kindle-Amazons-Wireless-Reading-Generation/dp/B00154JDAI
- Netbook computers (US $300+)
  - The Netbook Effect: How Cheap Little Laptops Hit the Big Time, http://www.wired.com/gadgets/wireless/magazine/17-03/mf_netbooks

Amazon Kindle 2 e-Reader

Sample Online Digital Resources

- Online textual material
  - eGranary Digital Library: over 10 million resources www.widernet.org/digitallibrary
  - Google Books: books.google.com
  - Project Gutenberg: www.gutenberg.org
- Online video material
  - YouTube: astounding numbers of educationally useful short and long video clips http://youtube.com

My Thoughts About Computer Resources

- Just providing equipment + software is not good enough
  - Must be integrated into curriculum
  - Teachers must truly know how to use it
  - Teachers must have proper support
- Properly done => Hard work and money
- Collaboration is necessary
- Properly done => Greatly enhanced learning

Return to the Five Questions

What do you think?

- Will computers be the teachers of the future?
- Does using computers result in better learning?
- Should we be spending more or less money for computer technology in education?
- What is constructivist learning and how are computers relevant?
- Do computers enable mastery learning?

Questions or Comments

- Your chance …
- P.S.: This presentation is available at http://seal.uom.ac.mu/Brandle
- My email: sbrandle@cse.taylor.edu

General Bibliography (1)

- "Can Automated Scoring Surpass Hand Grading of Students' Constructed Responses and Error Patterns in Mathematics?". Nava L. Livne, Oren E. Livne, and Charles A. Wight. MERLOT Journal of Online Learning and Teaching Vol. 3, No. 3, September 2007. http://jolt.merlot.org/vol3no3/livne.pdf. Verified 2009/05/27.
- "Transforming Course Design -- Calculus in the new Millennium". http://calculus.sfsu.edu/transforming/. Verified 2009/05/27.
- "Comparing The Validity of Automated And Human Scoring OF Essays", Donald E. Powers, Jill C. Burstein, Martin S. Chodorow, Mary E. Fowles, Karen Kukich (all from Educational Testing Service, Princeton, New Jersey), Journal of Educational Computing Research, Volume 26, Number 4 / 2002, pp. 407 – 425.
- "Automatic essay assessment". Tuomo Kakkonen. http://cs.joensuu.fi/~tkakkone/essay_assessment.html, Verified 2009/05/27.

General Bibliography (2)

- "How People Learn: Brain, Mind, Experience, and School". John D. Bransford, Ann L. Brown, and Rodney R. Cocking, eds., Commission on Behavioral and Social Sciences and Education, National Academic Press, 2000.
- "The Netbook Effect: How Cheap Little Laptops Hit the Big Time", Clive Thompson, Wired Magazine, February 2009. http://www.wired.com/gadgets/wireless/magazine/17-03/mf_netbooks. Verified 2009/05/27.
- "Crucial Issues in the Field of Educational, Instructional & School Psychology", Gabi Salomon. http://www.ucm.es/info/Psyap/iaap/salomon.htm. Verified 2009/05/25.

Bibliography: Web Resources

- COW: Calculus on the Web. http://cow.math.temple.edu/~cow/cgi-bin/tourguide. Verified 2009/05/27.
- eGranary Digital Library. www.widernet.org/digitallibrary. Verified 2009/05/22.
- Google Books. books.google.com. Verified 2009/05/27.
- Project Gutenberg. www.gutenberg.org. Verified 2009/05/25.
- Web-CAT: Web Center for Automated Testing. http://web-cat.cs.vt.edu/. Verified 2009/05/26.

Bibliography: Videos

- "EA Sim City Society Interview", interview by Kidconfidence, http://www.youtube.com/watch?v=XxA8jmknx4g, downloaded 2009/05/26.
- "SimCity Societies Trailer", Electronic Arts, http://www.youtube.com/watch?v=7CITnQz7V3M&feature=related, downloaded 2009/05/27.
- "SimCity Societies Trailer 2", Electronic Arts, http://www.youtube.com/watch?v=jpAJ4368Gws&feature=related, downloaded 2009/05/27.
- "SimCity 4 Rush Hour Demo", http://www.youtube.com/watch?v=HuLhmLmORU0, downloaded 2009/05/27.
- "Amazon Kindle 2 Review", http://www.youtube.com/watch?v=3cktgAwu3AE, downloaded 2009/05/27.
- "Maple TA", http://www.maplesoft.com/products/mapleta/Demo/index.aspx, verified 2009/05/27.