A system to teach

Introductory Programming

People…

- Rajdeep Das (IITK)
- Umair Z Ahmed (IITK)
- Naman Bansal (IITK)
- Ivan Radiček (VUT)
- Several Interns
- Sumit Gulwani (MSR, IITK)
- Amey Karkare (IITK)
- More students are added …

Challenges

- Teaching 1st level programming course is difficult
- Specially in India
  - Lack of proper infrastructure
  - Many Languages (not the **programming** languages)
- Wide gap in the level of exposure to computers
  - Competitive-programmers to Not-even-seen-a-computer-yet!

Major Challenges for us

- How to keep good programmers engaged while teaching simple stuff to beginners?
- How to provide early feedback?
- Without too many extra resources
  - Limited TA support
  - Varying expertise of TAs
  - Nobody likes to work extra hours ☹
- Use of existing computers
  - Various flavors of OSes

Solution? Motivation!

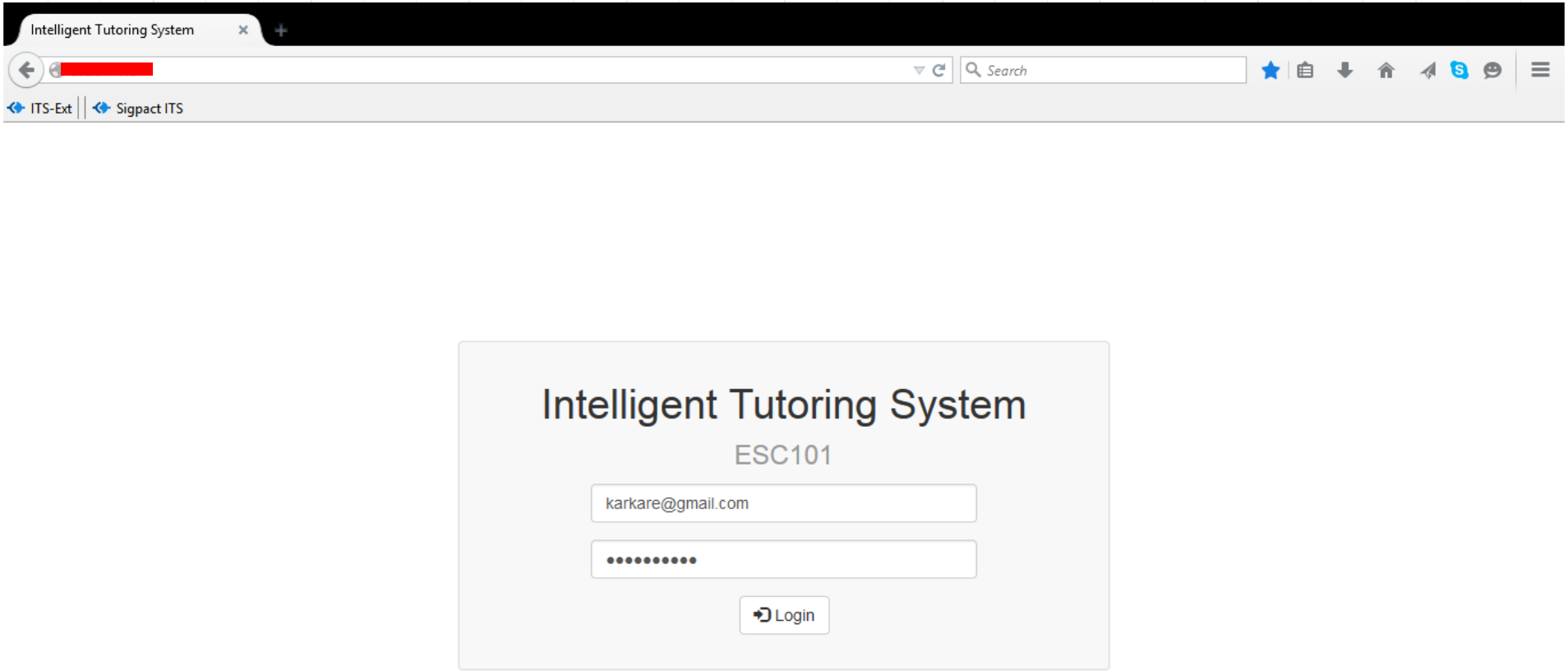
- Code Hunt ?
  - Talk with Judith in Sept 2013 to use it at IIT Kanpur
  - Did not work out (for several different reasons)
- IDEone ?
  - Browser based IDE
  - Nothing else!

Setup

- ESC101 @ IIT Kanpur
- Approx 400 students every semester
- Weekly Load
  - for student: 3 Lectures, 1 Tutorial, 1 Lab
  - for instructor: 3 Lectures, 1 Tutorial (summarize the week, do-s and don't-s, quizzes, ...), 4 Labs (?)
- Other courses have labs too!
  - Space and time table issues => class divided into 4 groups with different lab days
  - ESC101 lab on M, Tu, W, Th

The System : Finally

- Its demo time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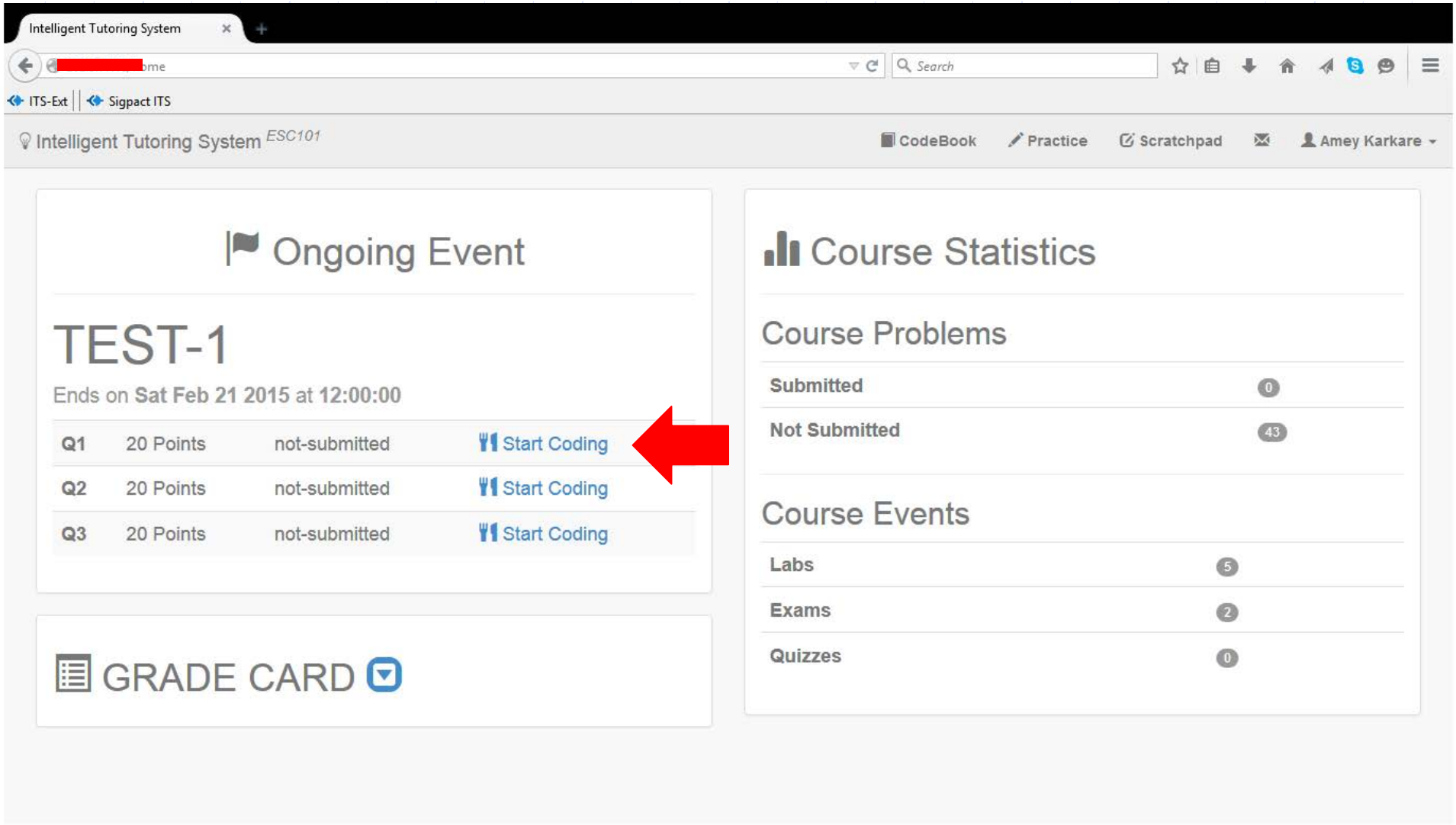
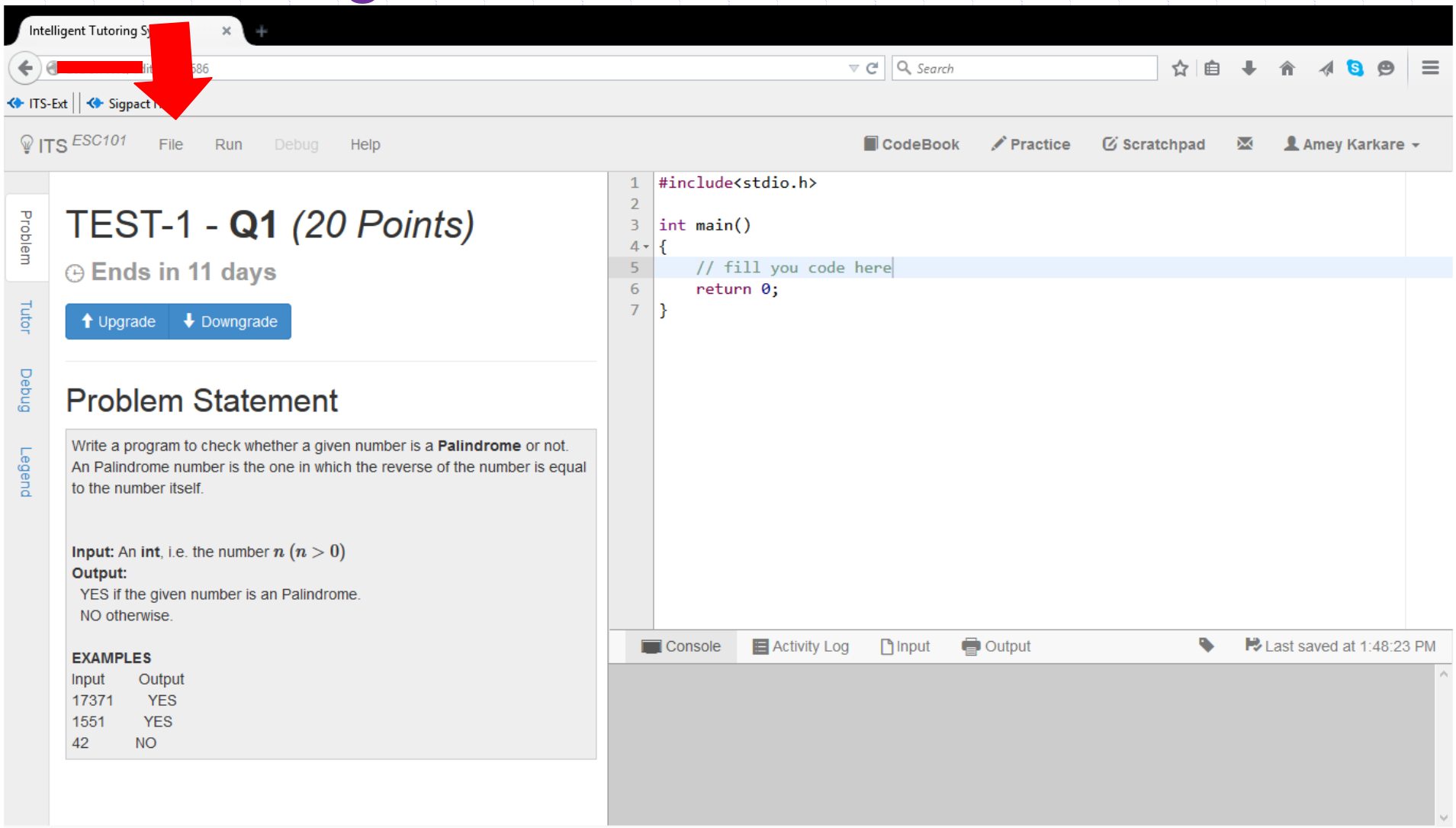
Sigpact ITS
Intelligent Tutoring System
ESC101
karkare@gmail.com
Login

Student Interface

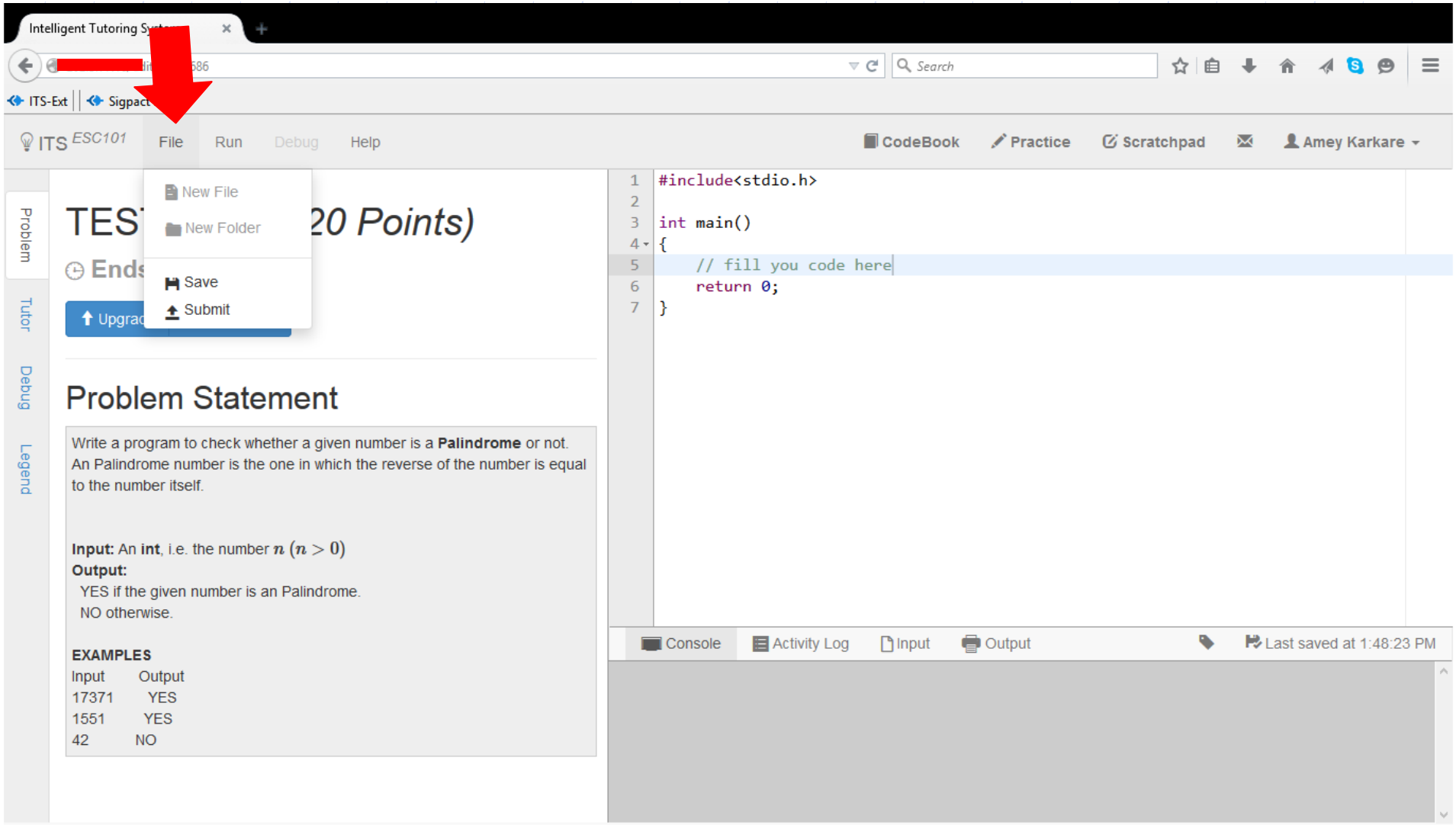
Dashboard


Intelligent Tutoring System
Search
ITS-Ext
Sigpact ITS
Intelligent Tutoring System ESC101
CodeBook
Practice
Scratchpad
Amey Karkare
Ongoing Event
TEST-1
Ends on Sat Feb 21 2015 at 12:00:00
Q1 20 Points not-submitted Start Coding
Q2 20 Points not-submitted Start Coding
Q3 20 Points not-submitted Start Coding
GRADE CARD
Course Statistics
Course Problems
Submitted 0
Not Submitted 43
Course Events
Labs 5
Exams 2
Quizzes 0

Coding Arena



File Menu


Intelligent Tutoring Sy
Search
ITS-Ext
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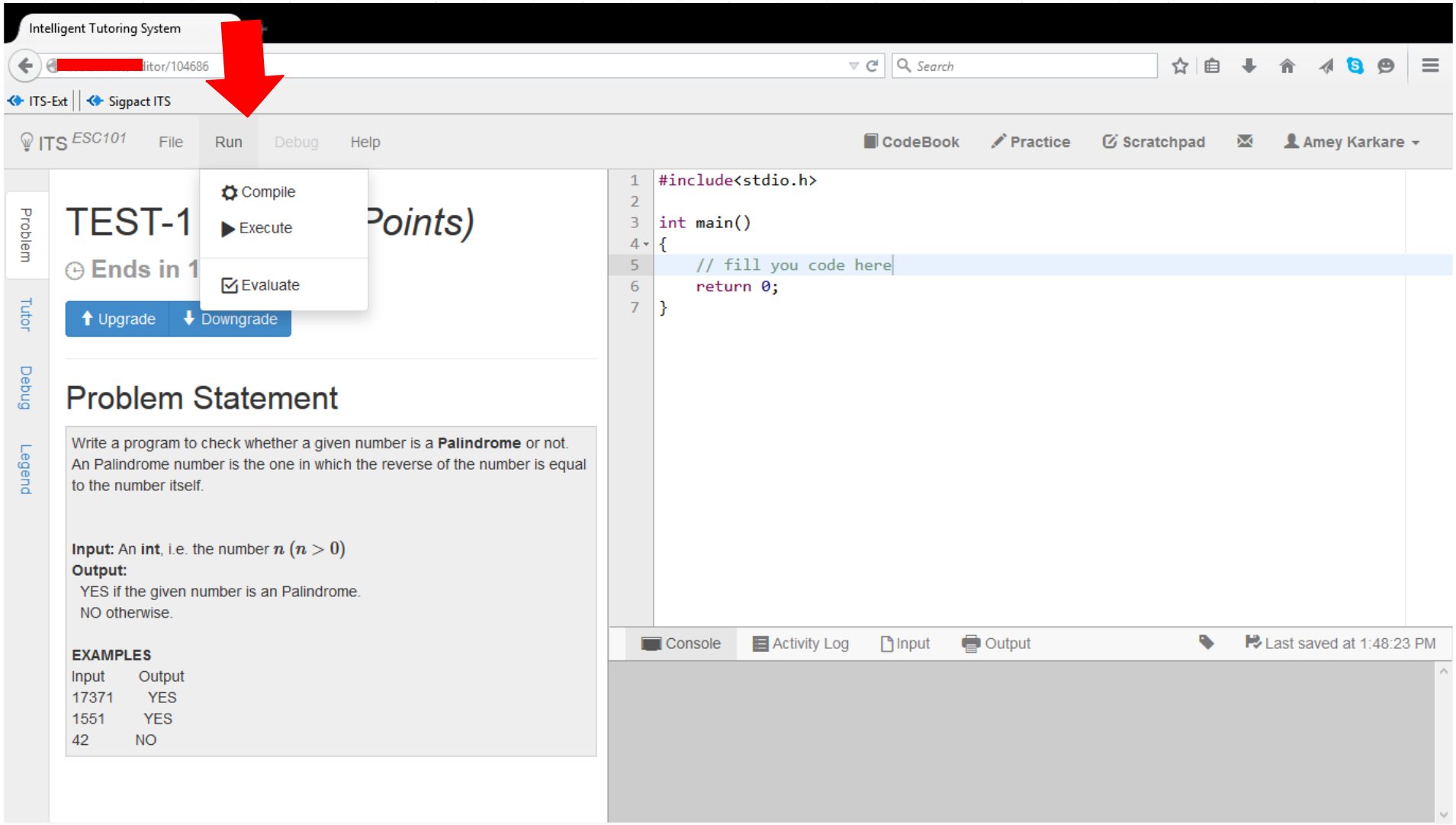
ITS ESC101
File
Run
Debug
Help
CodeBook
Practice
Scratchpad
Amey Karkare
New File
New Folder
Save
Submit
Problem
Tutor
Debug
Legend
TEST
20 Points)
Ends
Upgrad
Problem Statement
Write a program to check whether a given number is a Palindrome or not.
An Palindrome number is the one in which the reverse of the number is equal to the number itself.
Input: An int, i.e. the number n $(n > 0)$
Output:
YES if the given number is an Palindrome.
NO otherwise.
EXAMPLES
Input Output
17371 YES
1551 YES
42 NO
1 #include<stdio.h>
2
3 int main()
4 {
5 // fill you code here
6 return 0;
7 }
Console
Activity Log
Input
Output
Last saved at 1:48:23 PM

Run Menu


Intelligent Tutoring System
ITS-Ext
Sigpact ITS
ITS ESC101
File
Run
Debug
Help
CodeBook
Practice
Scratchpad
Amey Karkare
Compile
Execute
Evaluate
Problem
Tutor
Debug
Legend
TEST-1
Points)
Ends in 1
Upgrade
Downgrade
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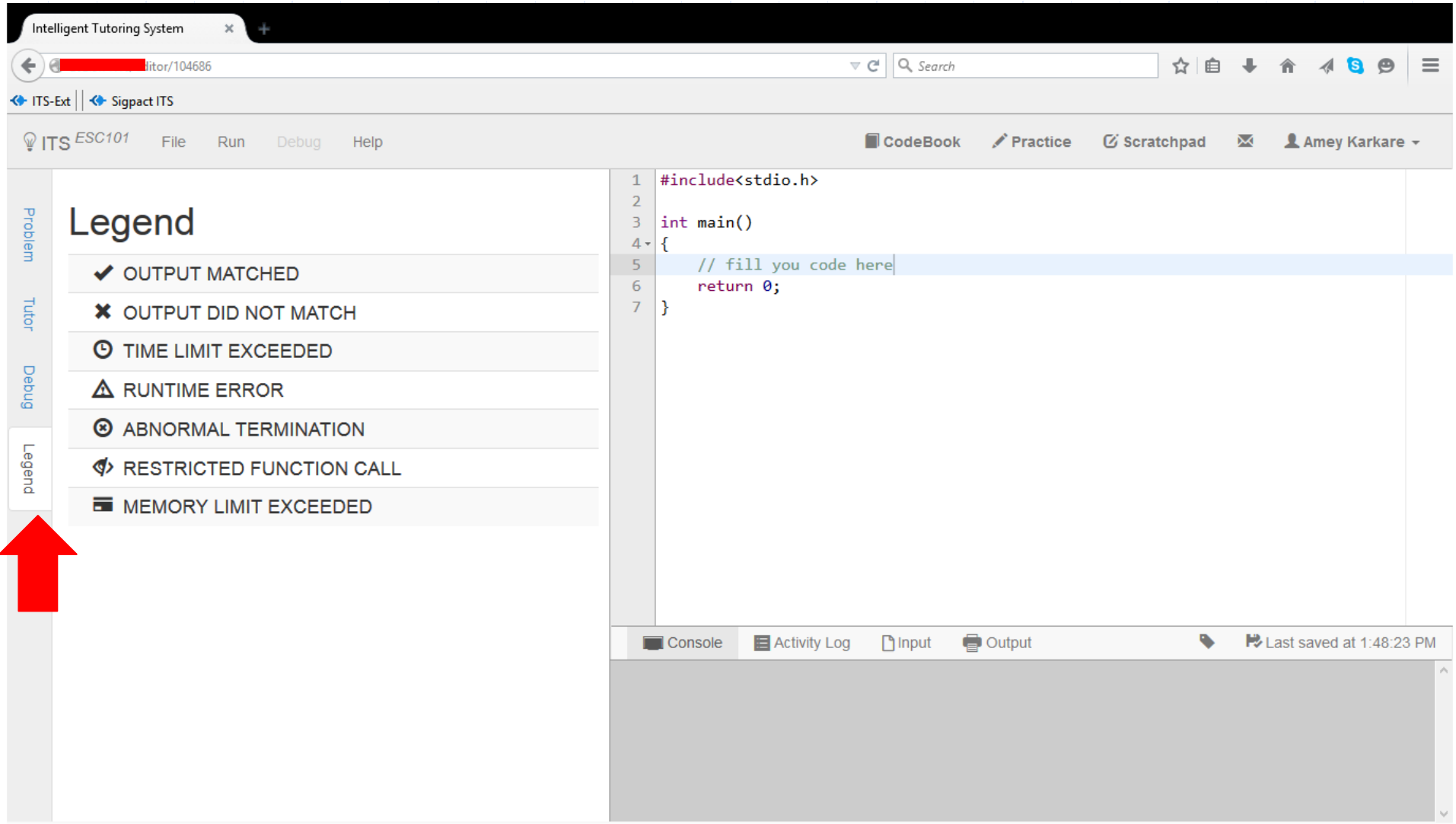
}
Console
Activity Log
Input
Output
Last saved at 1:48:23 PM

Tabs


Intelligent Tutoring System
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Search
ITS-Ext
Sigpact ITS
ITS ESC101
File
Run
Debug
Help
CodeBook
Practice
Scratchpad
Amey Karkare
Problem
Tutor
Debug
Legend
Legend
OUTPUT MATCHED
OUTPUT DID NOT MATCH
TIME LIMIT EXCEEDED
RUNTIME ERROR
ABNORMAL TERMINATION
RESTRICTED FUNCTION CALL
MEMORY LIMIT EXCEEDED
1 #include<stdio.h>
2
3 int main()
4 {
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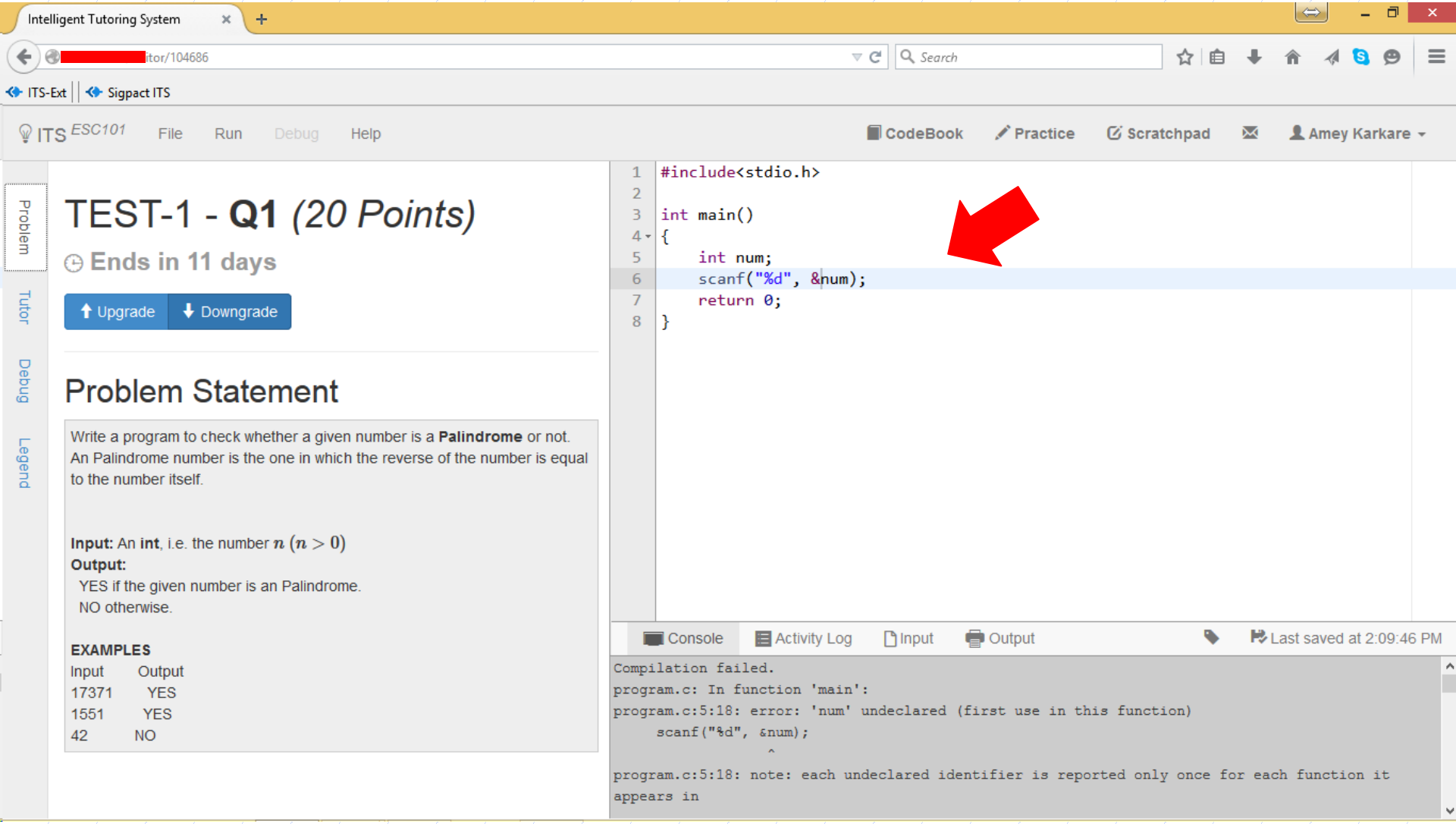
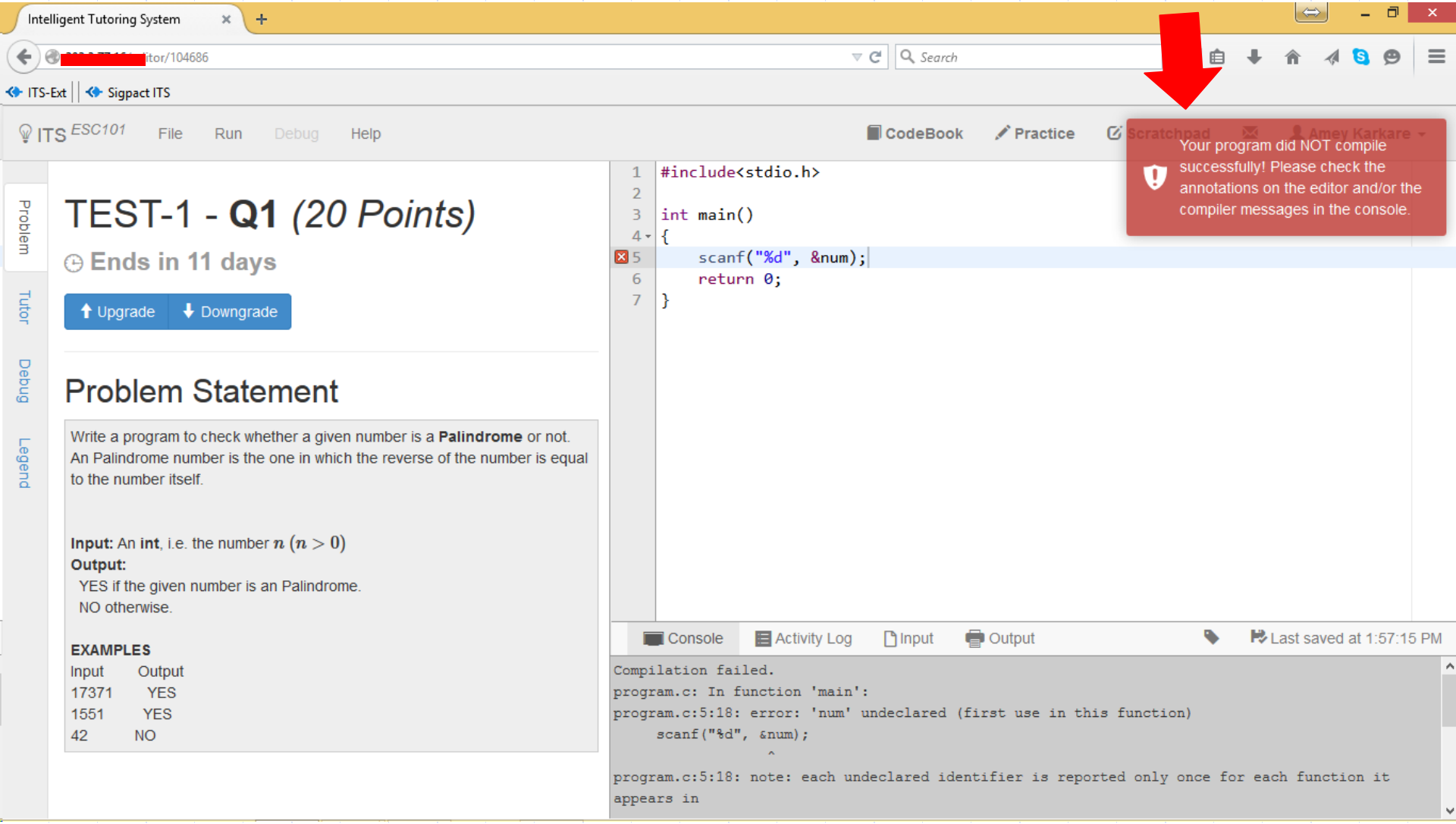
6 return 0;
7 }
Console
Activity Log
Input
Output
Last saved at 1:48:23 PM

Editor Window



Run → Compile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Sigpact ITS
ITS ESC101
File
Run
Debug
Help
CodeBook
Practice
Scratchpad
Amey Karkare
Your program did NOT compile successfully! Please check the annotations on the editor and/or the compiler messages in the console.
Problem
Tutor
Debug
Legend
TEST-1 - Q1 (20 Points)
Ends in 11 days
Upgrade
Downgrade
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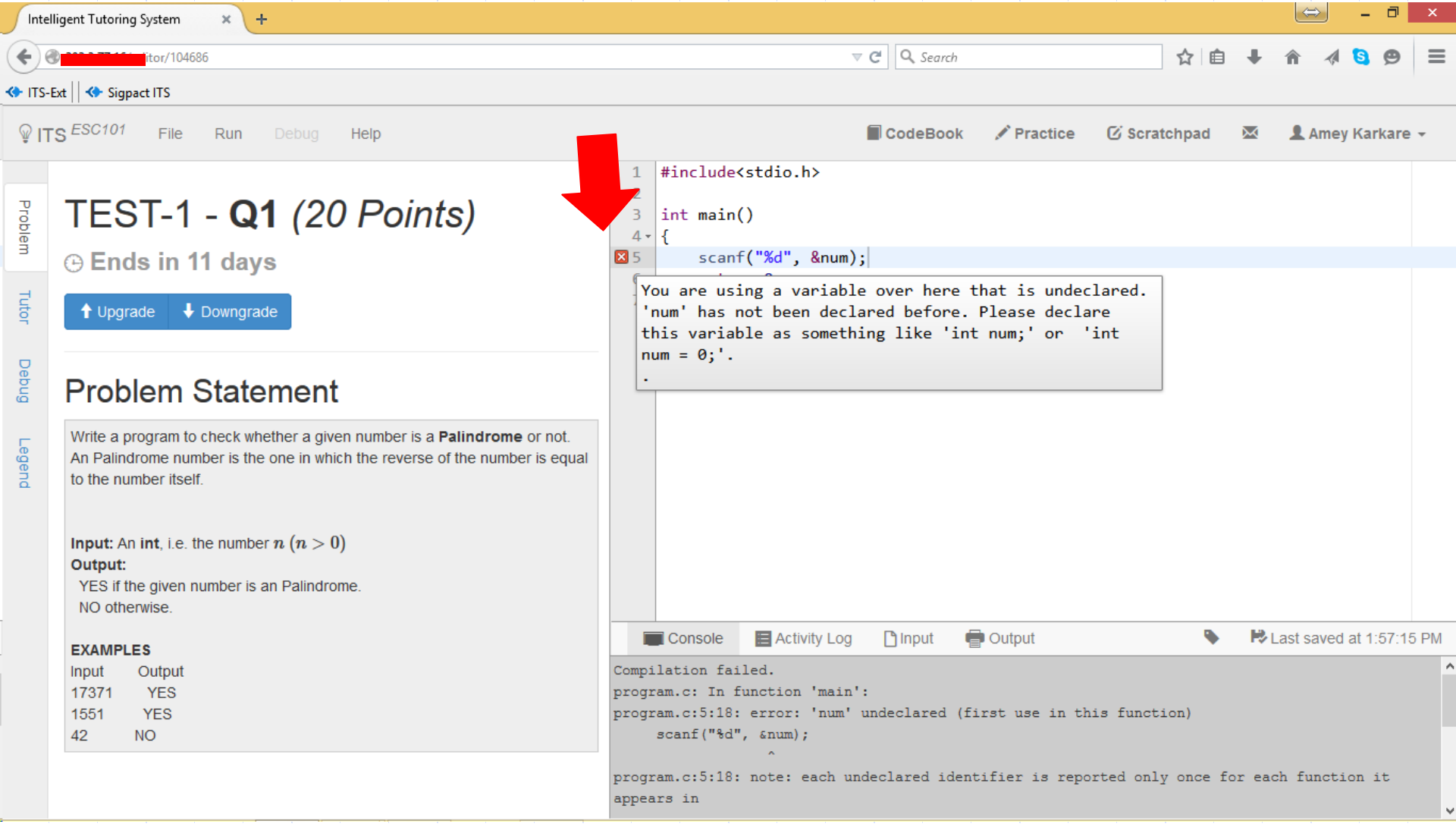
42 NO
1 #include<stdio.h>
2
3 int main()
4 {
5 scanf("%d", &num);
6 return 0;
7 }
Console
Activity Log
Input
Output
Last saved at 1:57:15 PM
Compilation failed.
program.c: In function 'main':
program.c:5:18: error: 'num' undeclared (first use in this function)
scanf("%d", &num);
^
program.c:5:18: note: each undeclared identifier is reported only once for each function it appears in

Run → Compile


Intelligent Tutoring System
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42 NO
#include<stdio.h>
int main()
{
scanf("%d", &num);
You are using a variable over here that is undeclared. 'num' has not been declared before. Please declare this variable as something like 'int num;' or 'int num = 0;'.
Console
Activity Log
Input
Output
Last saved at 1:57:15 PM
Compilation failed.
program.c: In function 'main':
program.c:5:18: error: 'num' undeclared (first use in this function)
scanf("%d", &num);
^
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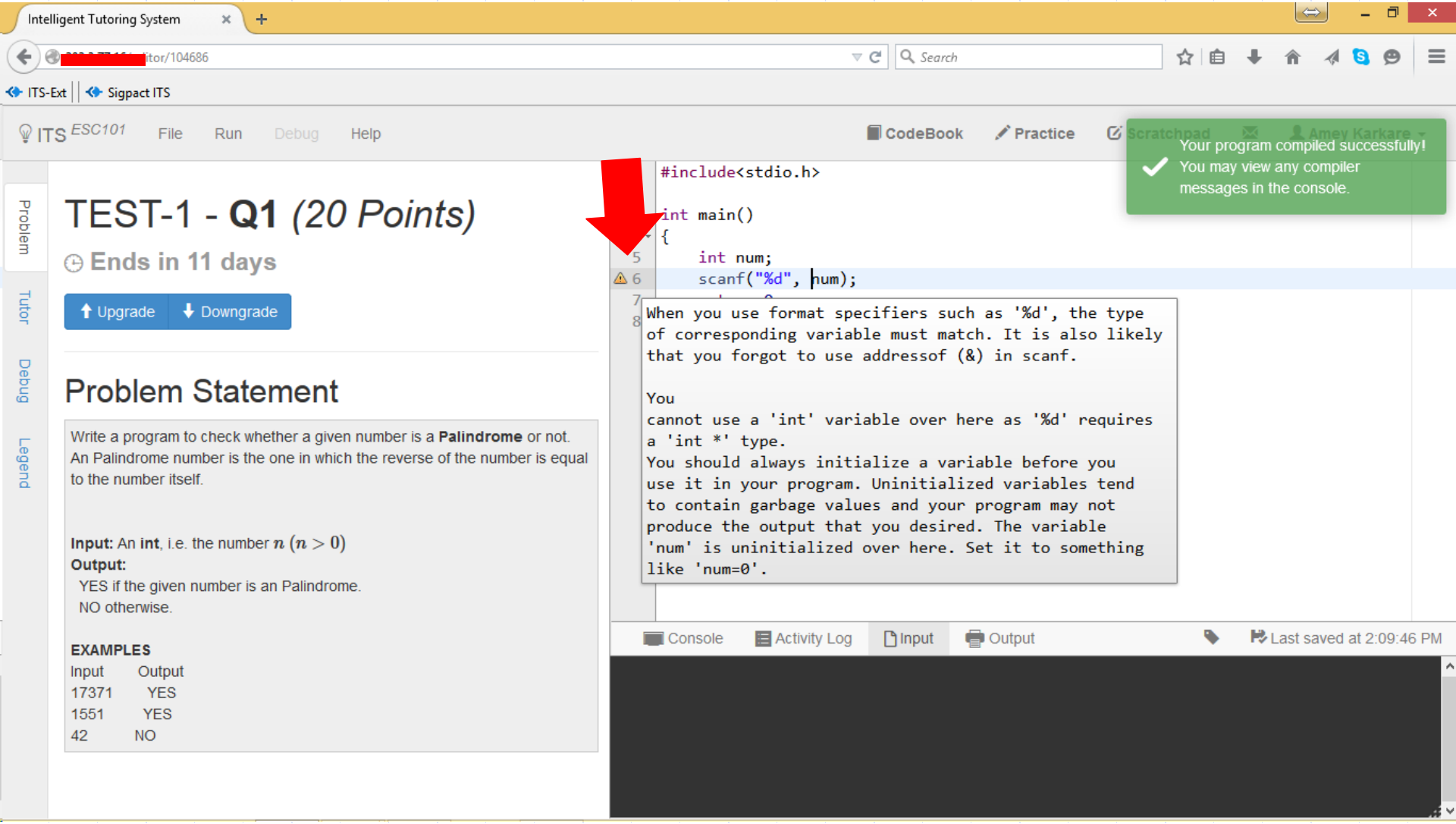
Run → Compile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Sigpact ITS
ITS ESC101
File
Run
Debug
Help
CodeBook
Practice
Scratchpad
Amey Karkare
Your program compiled successfully!
You may view any compiler messages in the console.
Problem
Tutor
Debug
Legend
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Ends in 11 days
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Downgrade
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NO otherwise.
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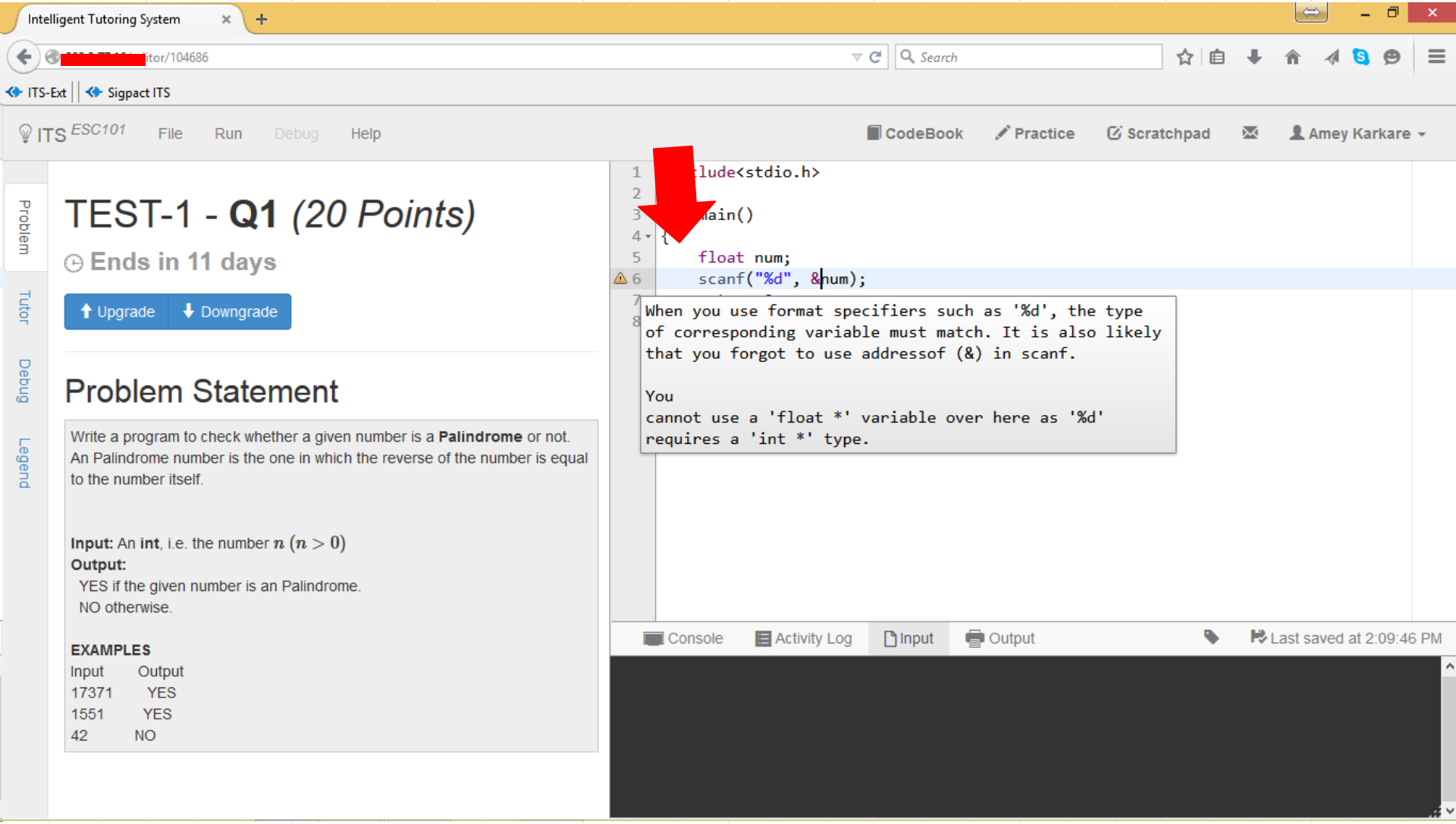
1551 YES
42 NO
#include<stdio.h>
int main()
{
int num;
scanf("%d", num);
When you use format specifiers such as '%d', the type of corresponding variable must match. It is also likely that you forgot to use addressof (&) in scanf.
You
cannot use a 'int' variable over here as '%d' requires a 'int *' type.
You should always initialize a variable before you use it in your program. Uninitialized variables tend to contain garbage values and your program may not produce the output that you desired. The variable 'num' is uninitialized over here. Set it to something like 'num=0'.
Console
Activity Log
Input
Output
Last saved at 2:09:46 PM

Run → Compile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File
Run
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CodeBook
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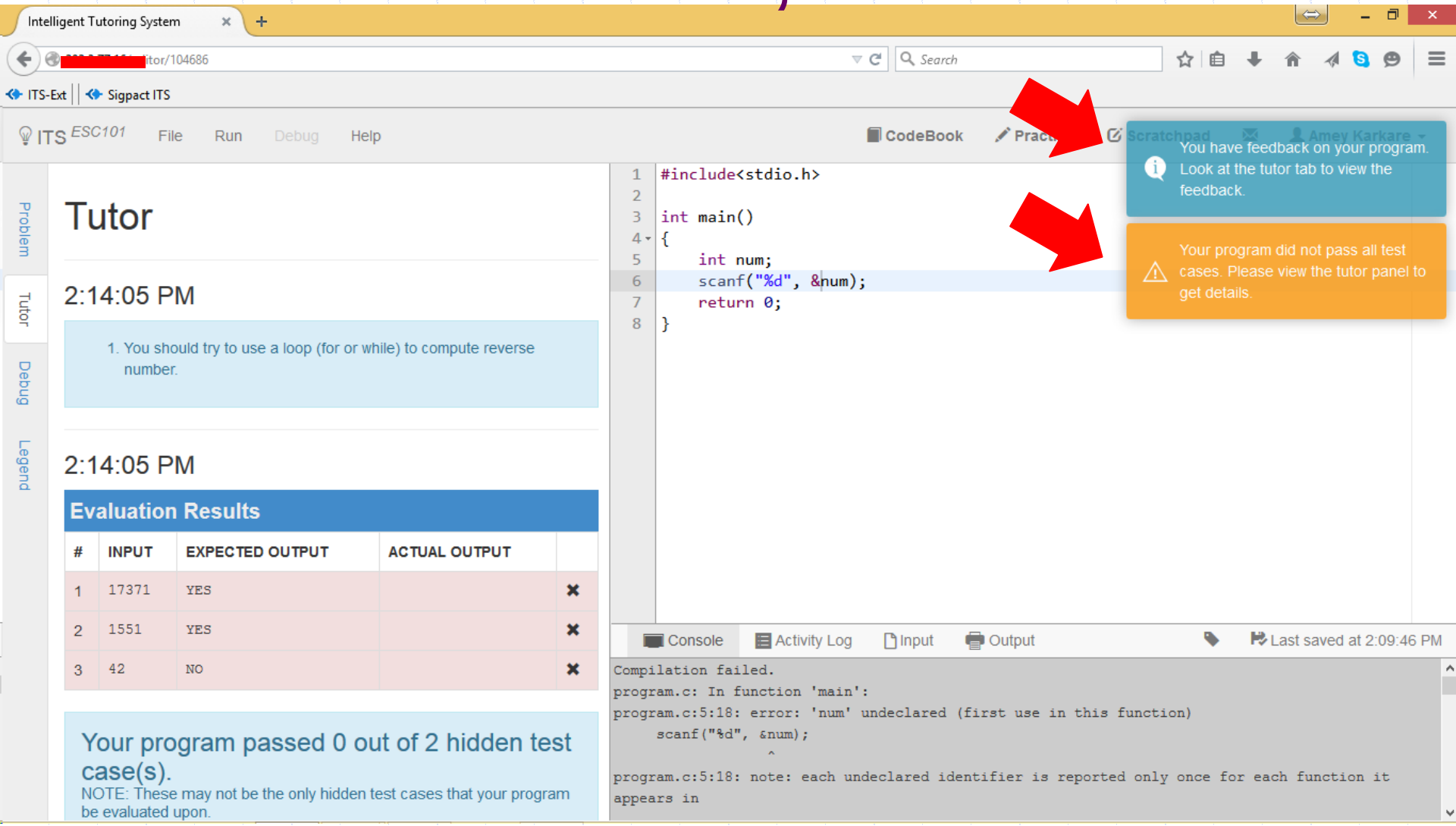
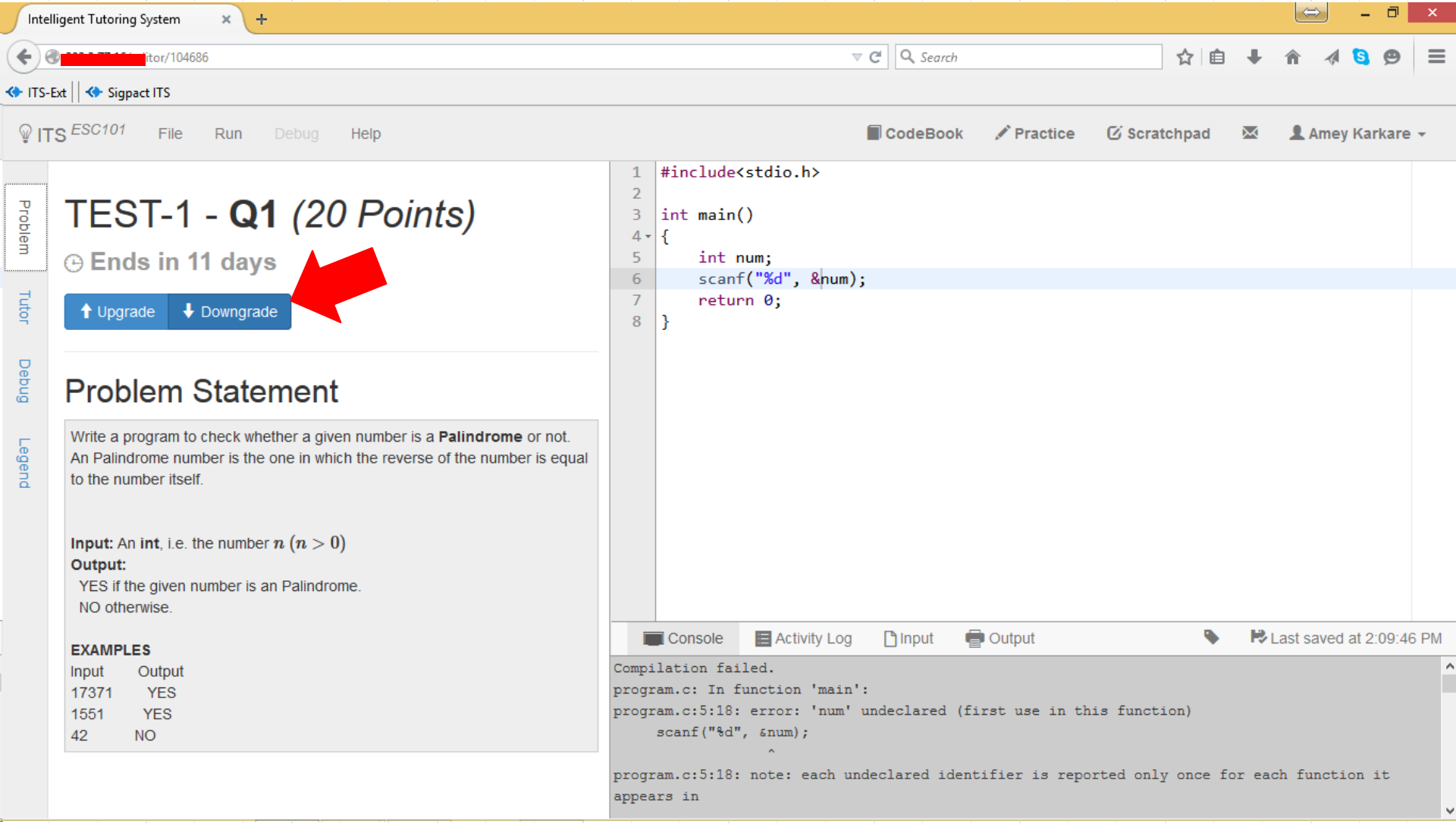
1551 YES
42 NO
1 lude<stdio.h>
2
3 ain()
4 {
5 float num;
6 scanf("%d", &num);
When you use format specifiers such as '%d', the type of corresponding variable must match. It is also likely that you forgot to use addressof (&) in scanf.
You
cannot use a 'float *' variable over here as '%d' requires a 'int *' type.
Console
Activity Log
Input
Output
Last saved at 2:09:46 PM

Run → Evaluate; Feedback



Downgrade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Sigpact ITS
ITS ESC101
File
Run
Debug
Help
CodeBook
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{
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scanf("%d", &num);
return 0;
}
Console
Activity Log
Input
Output
Last saved at 2:09:46 PM
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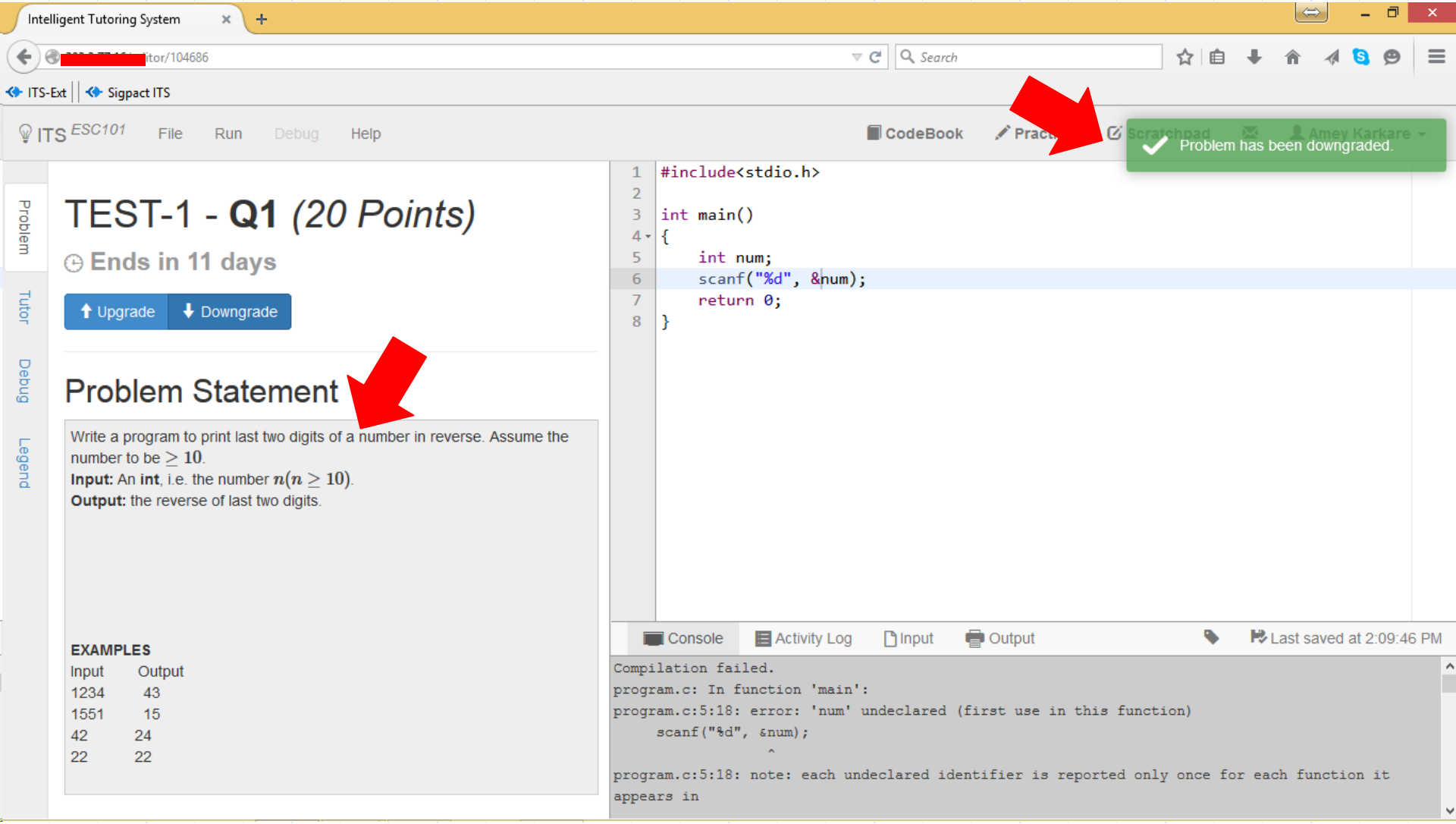
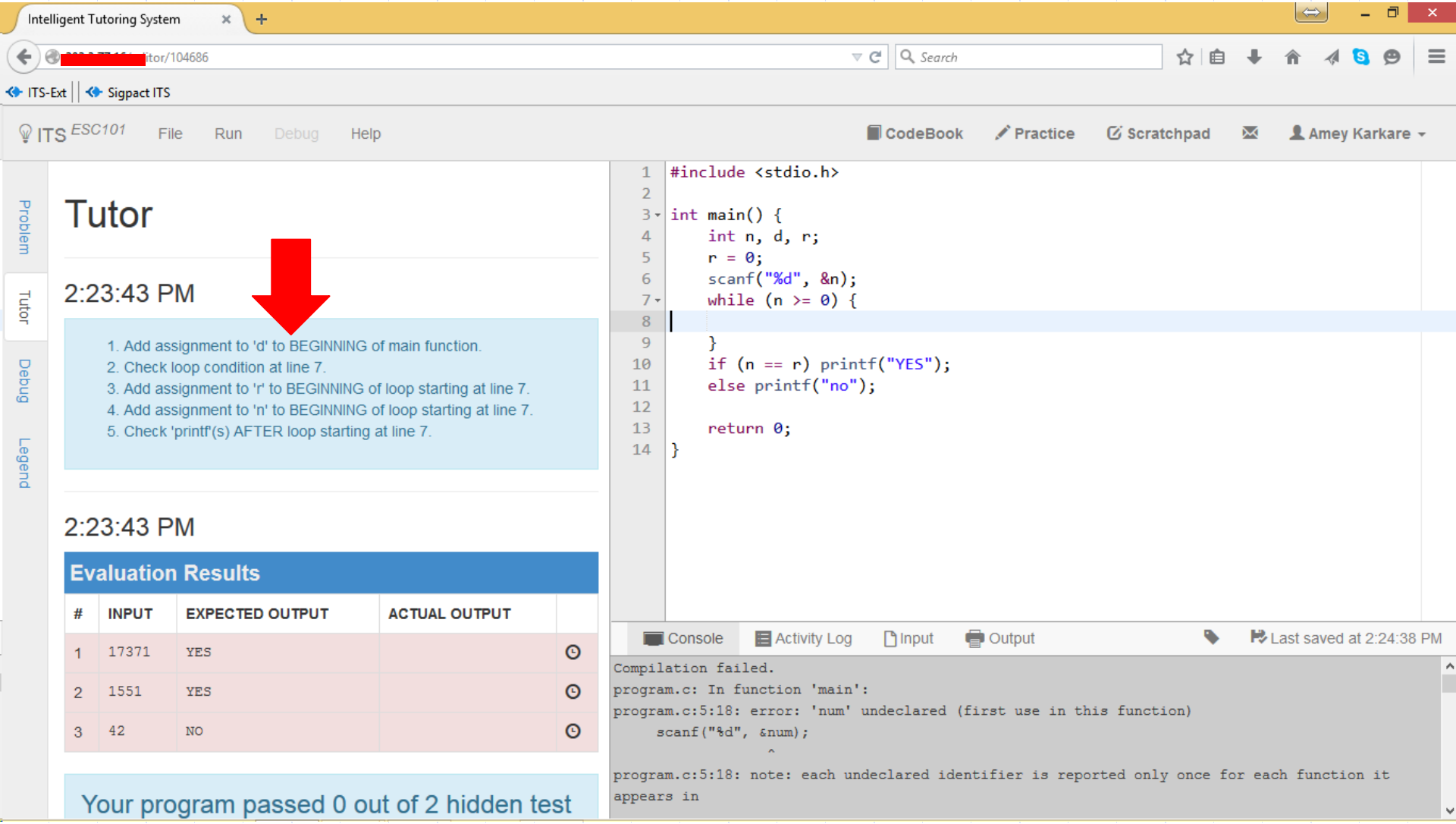
program.c: In function 'main':
program.c:5:18: error: 'num' undeclared (first use in this function)
scanf("%d", &num);
^
program.c:5:18: note: each undeclared identifier is reported only once for each function it appears in

Downgraded Problem



Feedback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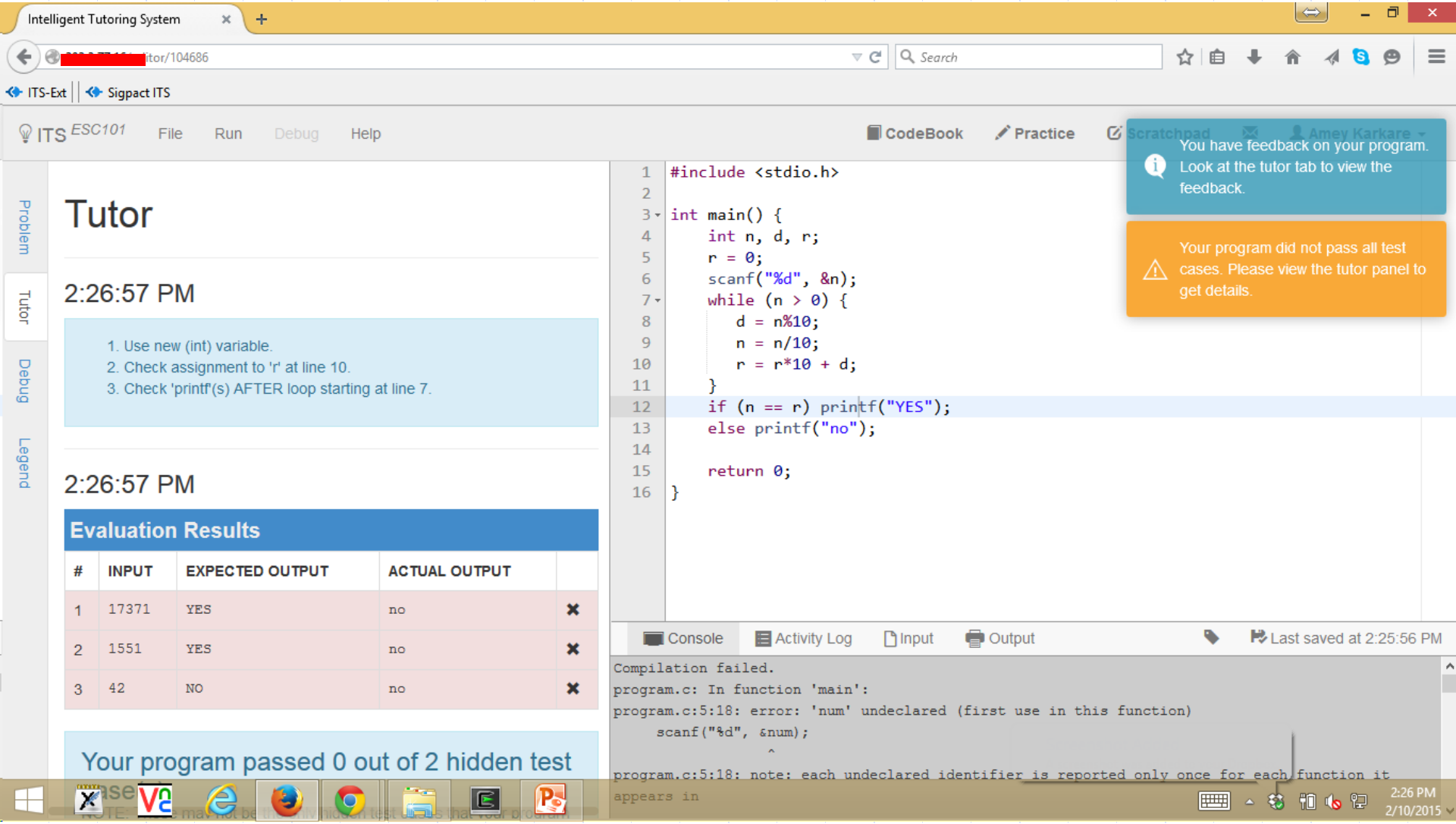
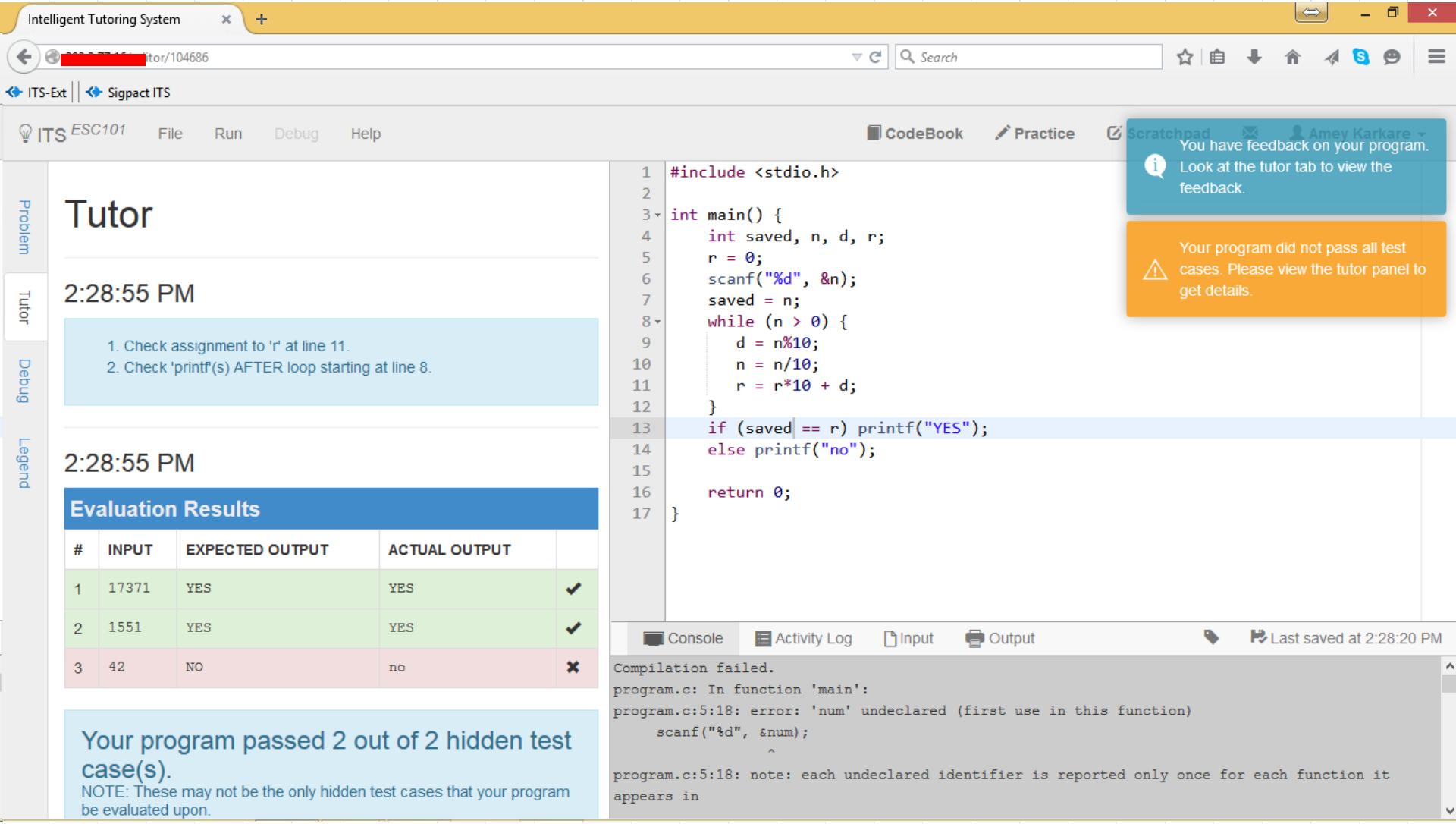
Sigpact ITS
ITS ESC101
File
Run
Debug
Help
CodeBook
Practice
Scratchpad
Amey Karkare
Problem
Tutor
Debug
Legend
Tutor
2:23:43 PM
1. Add assignment to 'd' to BEGINNING of main function.
2. Check loop condition at line 7.
3. Add assignment to 'r' to BEGINNING of loop starting at line 7.
4. Add assignment to 'n' to BEGINNING of loop starting at line 7.
5. Check 'printf'(s) AFTER loop starting at line 7.
2:23:43 PM
Evaluation Results
INPUT EXPECTED OUTPUT ACTUAL OUTPUT
1 17371 YES
2 1551 YES
3 42 NO
Your program passed 0 out of 2 hidden test
#include <stdio.h>
int main() {
int n, d, r;
r = 0;
scanf("%d", &n);
while (n >= 0) {
}
if (n == r) printf("YES");
else printf("no");
return 0;
}
Console
Activity Log
Input
Output
Last saved at 2:24:38 PM
Compilation failed.
program.c: In function 'main':
program.c:5:18: error: 'num' undeclared (first use in this function)
scanf("%d", &num);
^
program.c:5:18: note: each undeclared identifier is reported only once for each function it appears in

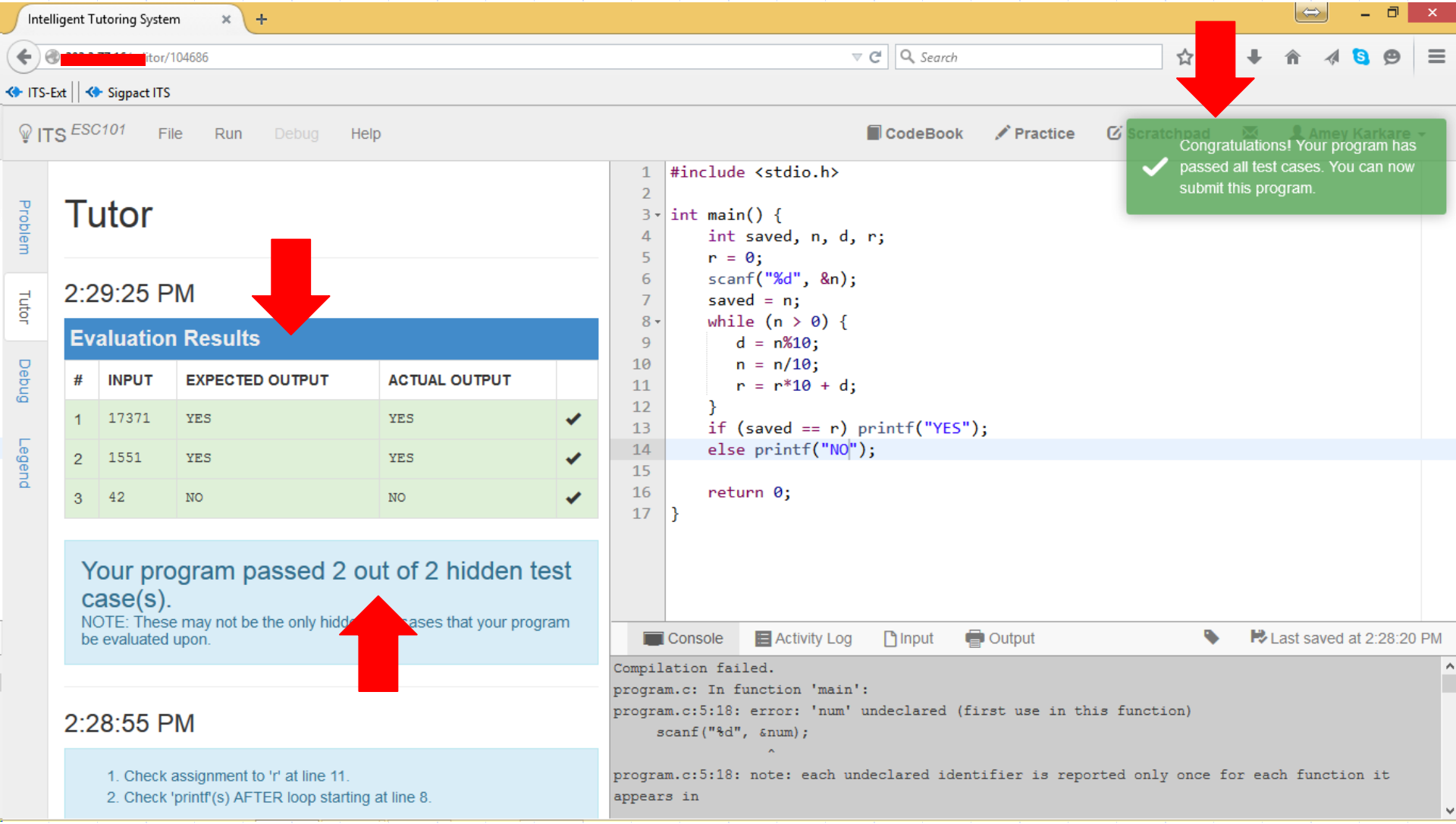
More Feedback



Even more Feedback



Success ☺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ITS ESC101
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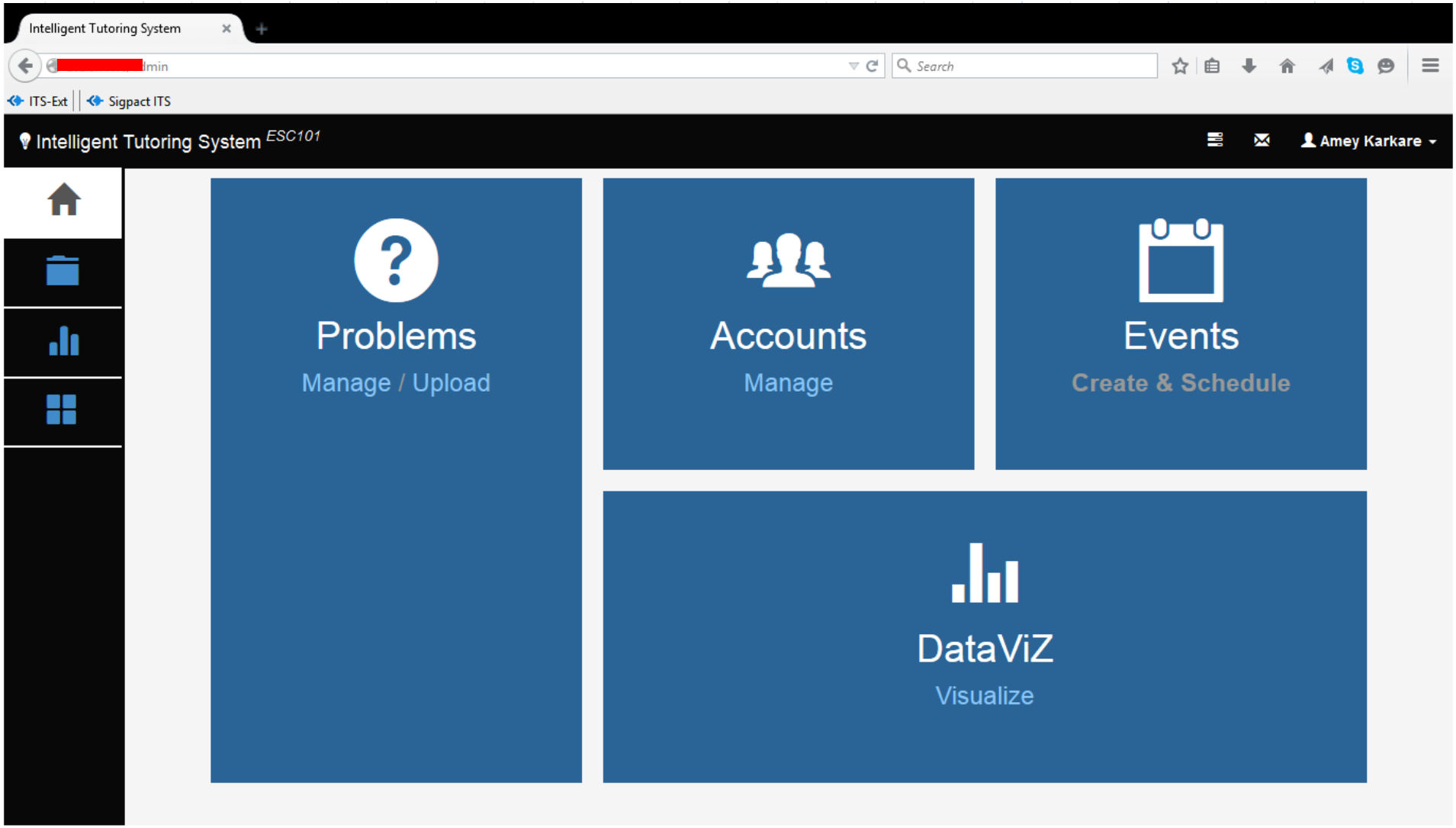
Help
CodeBook
Practice
Scratchpad
Congratulations! Your program has passed all test cases. You can now submit this program.
Problem
Tutor
Debug
Legend
Tutor
2:29:25 PM
Evaluation Results
INPUT EXPECTED OUTPUT ACTUAL OUTPUT
1 17371 YES YES
2 1551 YES YES
3 42 NO NO
Your program passed 2 out of 2 hidden test case(s).
2:28:55 PM
1. Check assignment to 'r' at line 11.
2. Check 'printf'(s) AFTER loop starting at line 8.
#include <stdio.h>
int main() {
int saved, n, d, r;
r = 0;
scanf("%d", &n);
saved = n;
while (n > 0) {
d = n%10;
n = n/10;
r = r*10 + d;
}
if (saved == r) printf("YES");
else printf("NO");
return 0;
}
Console
Activity Log
Input
Output
Last saved at 2:28:20 PM
Compilation failed.
program.c: In function 'main':
program.c:5:18: error: 'num' undeclared (first use in this function)
scanf("%d", &num);
program.c:5:18: note: each undeclared identifier is reported only once for each function it appears in

Admin Interface

Dashboard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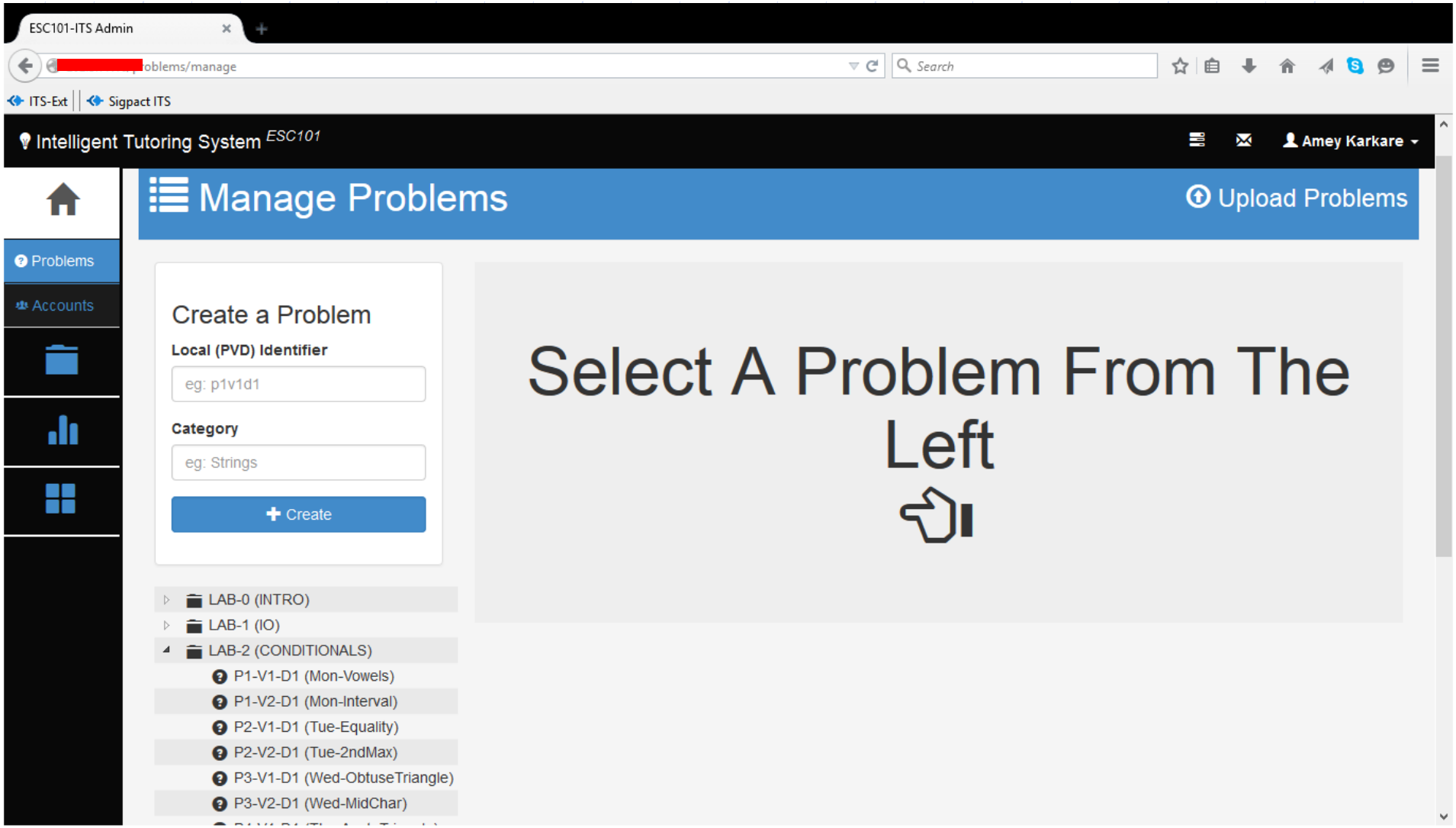
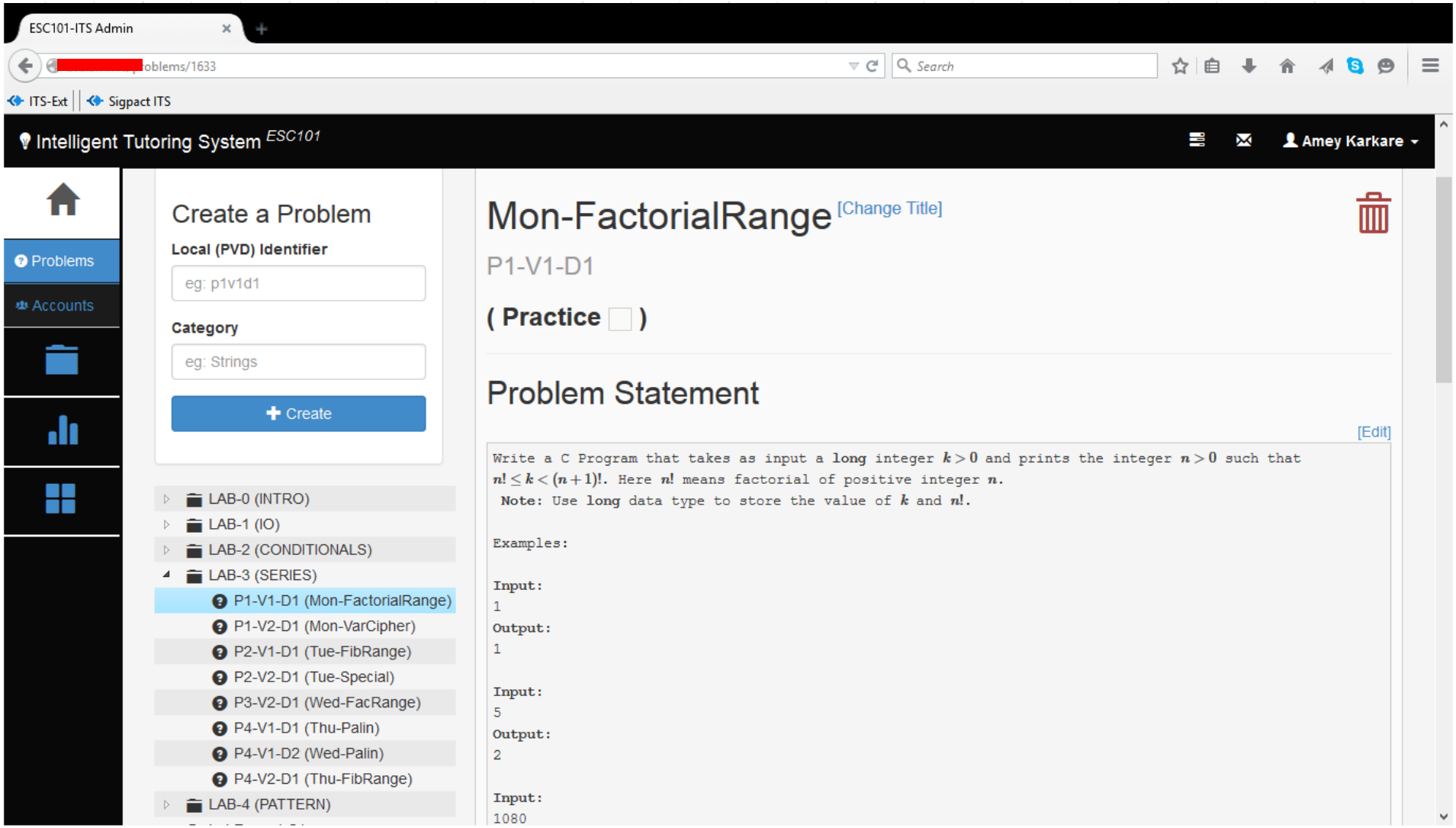
Problems
Manage / Upload
Accounts
Manage
Events
Create & Schedule
DataViZ
Visualize

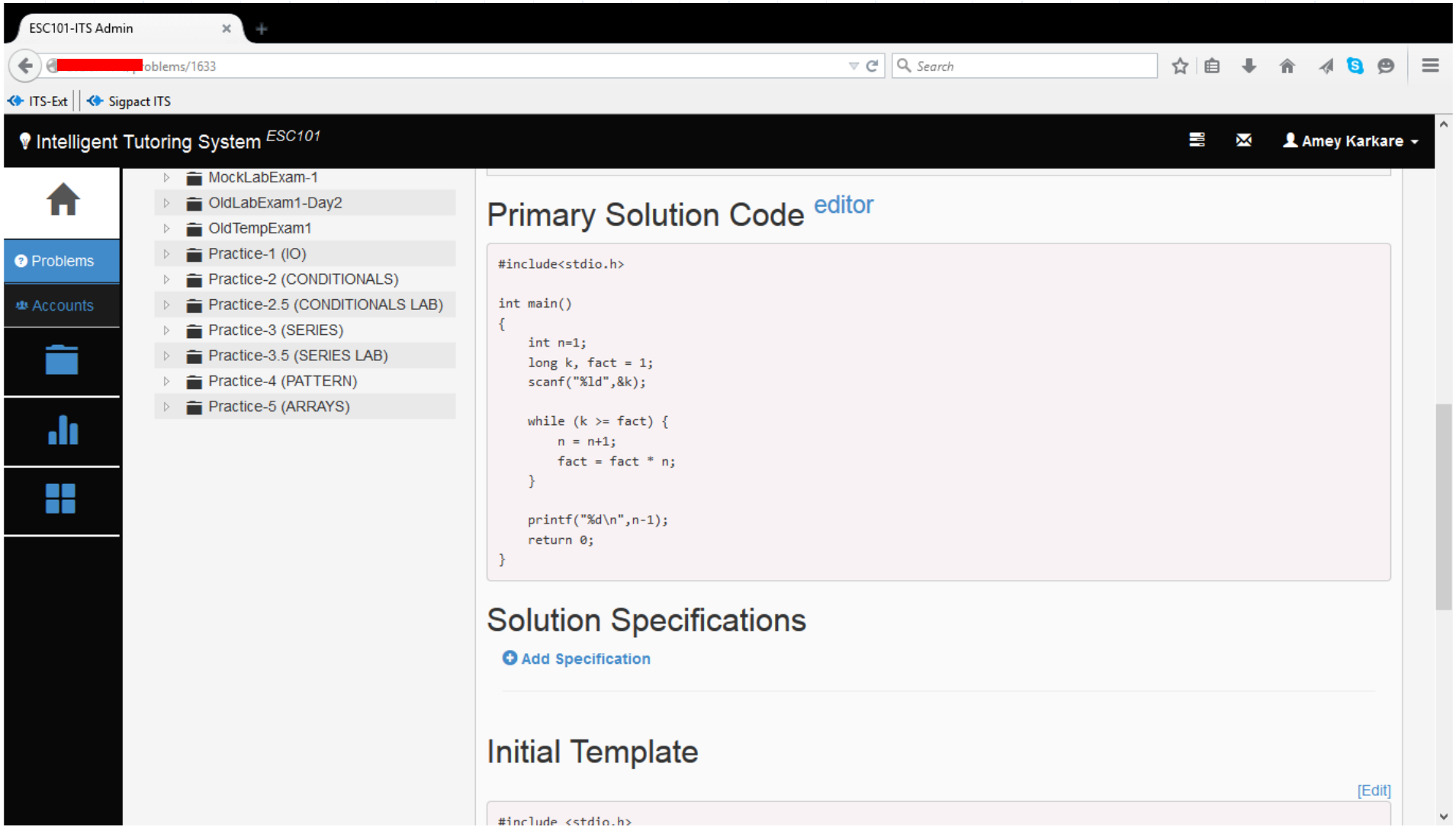
Problem Management



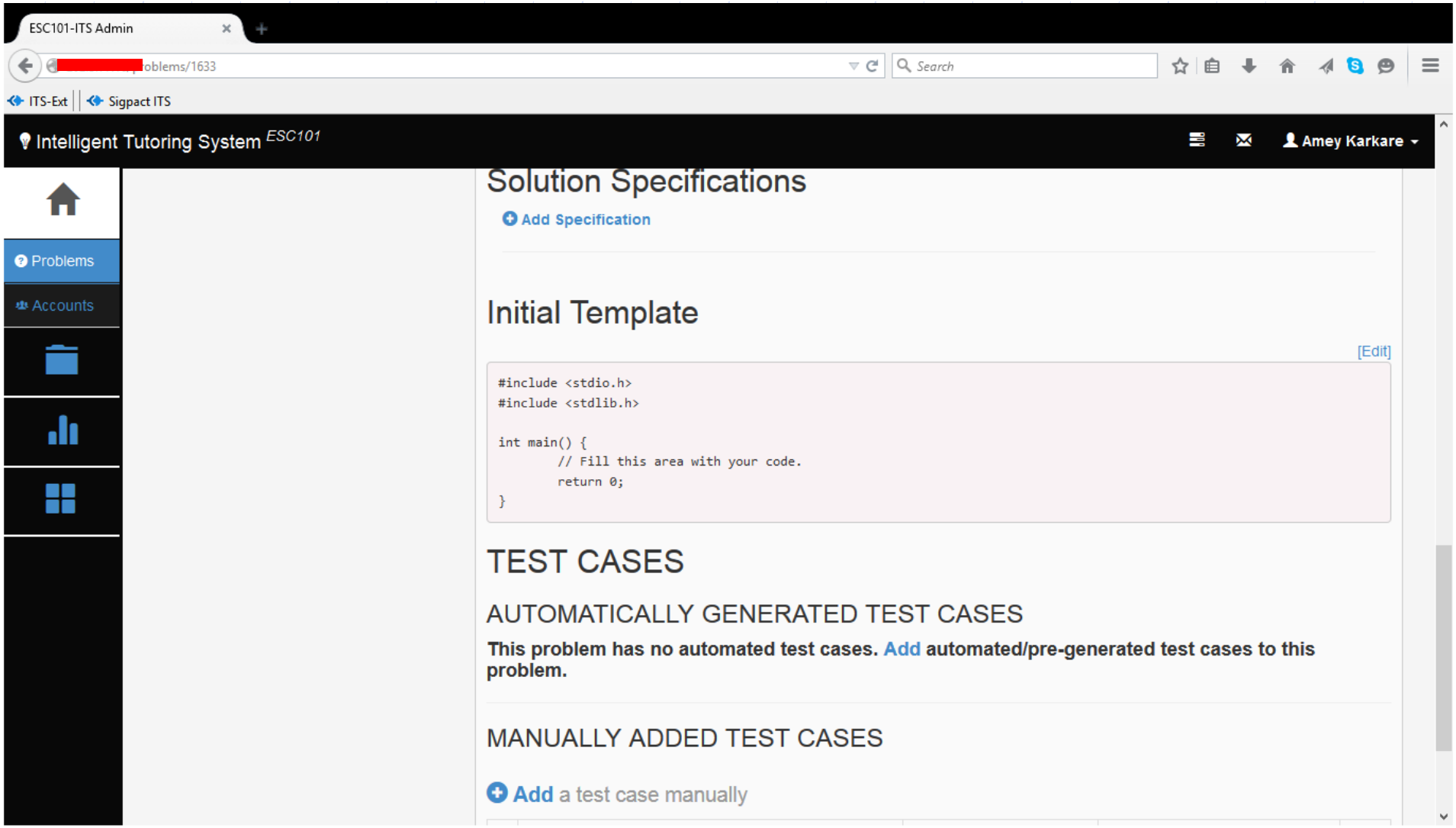
Problem Statement



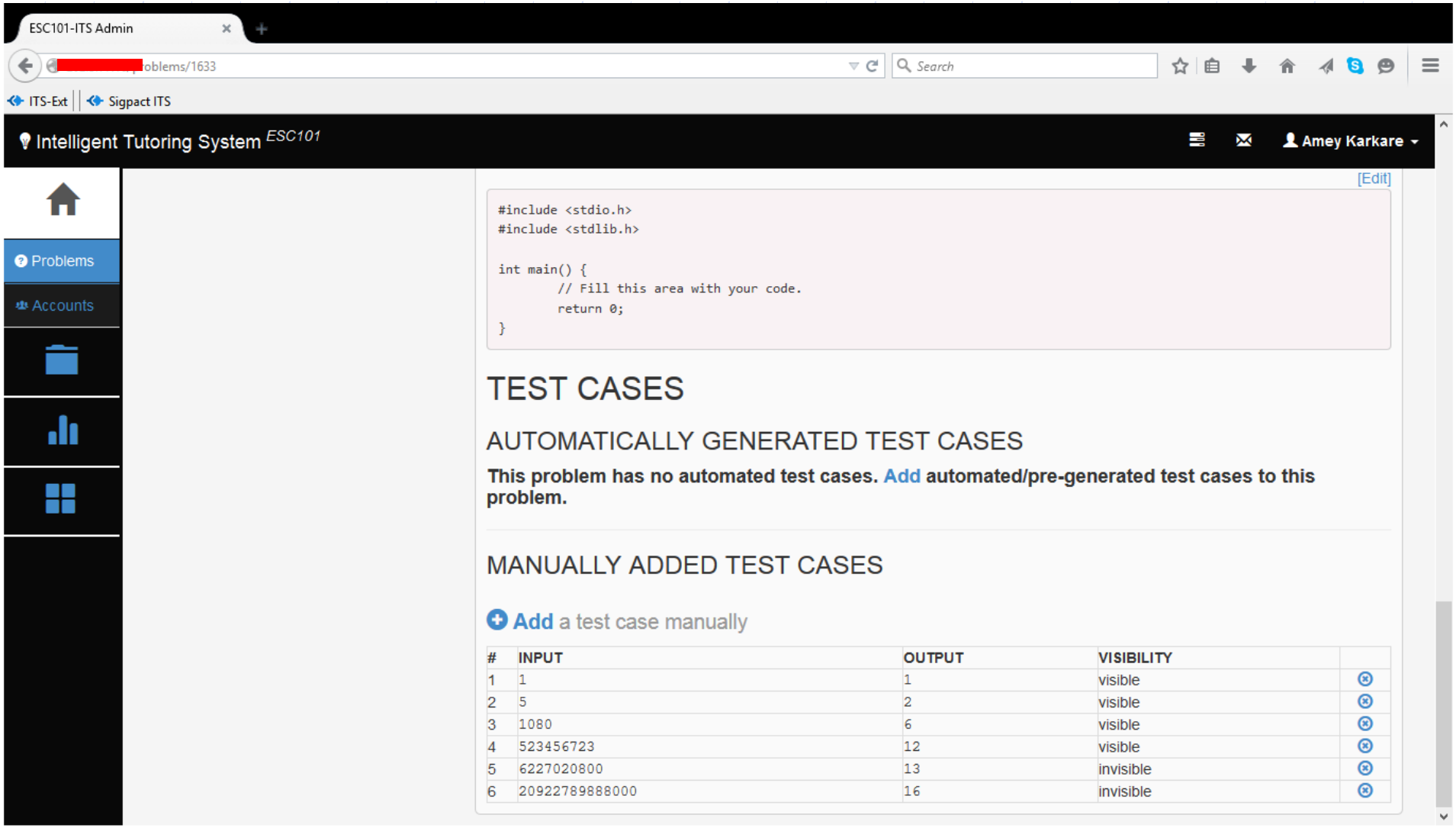
Instructor's Solution



Specifications and Template

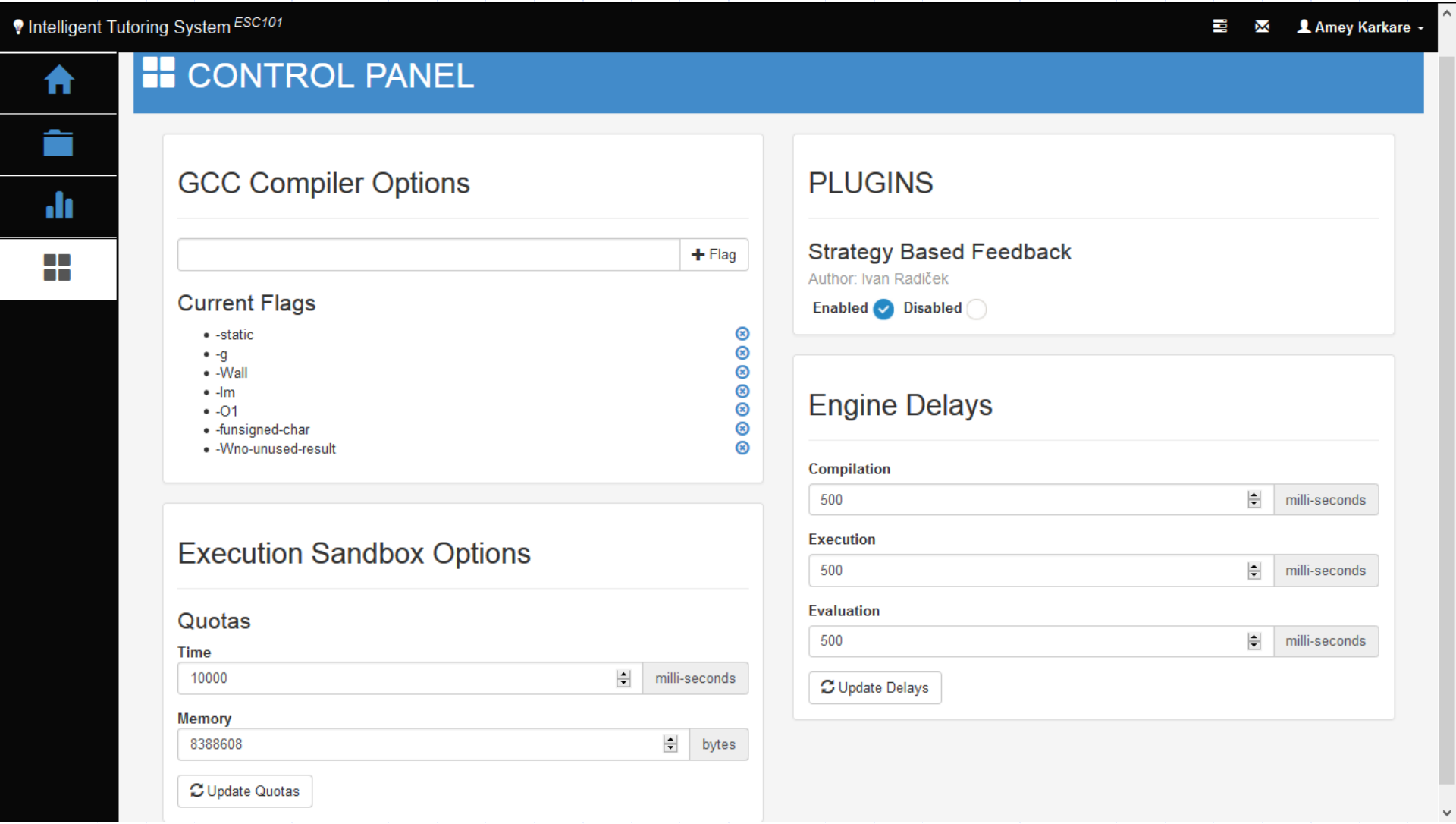


Testcases: Automated & Manual

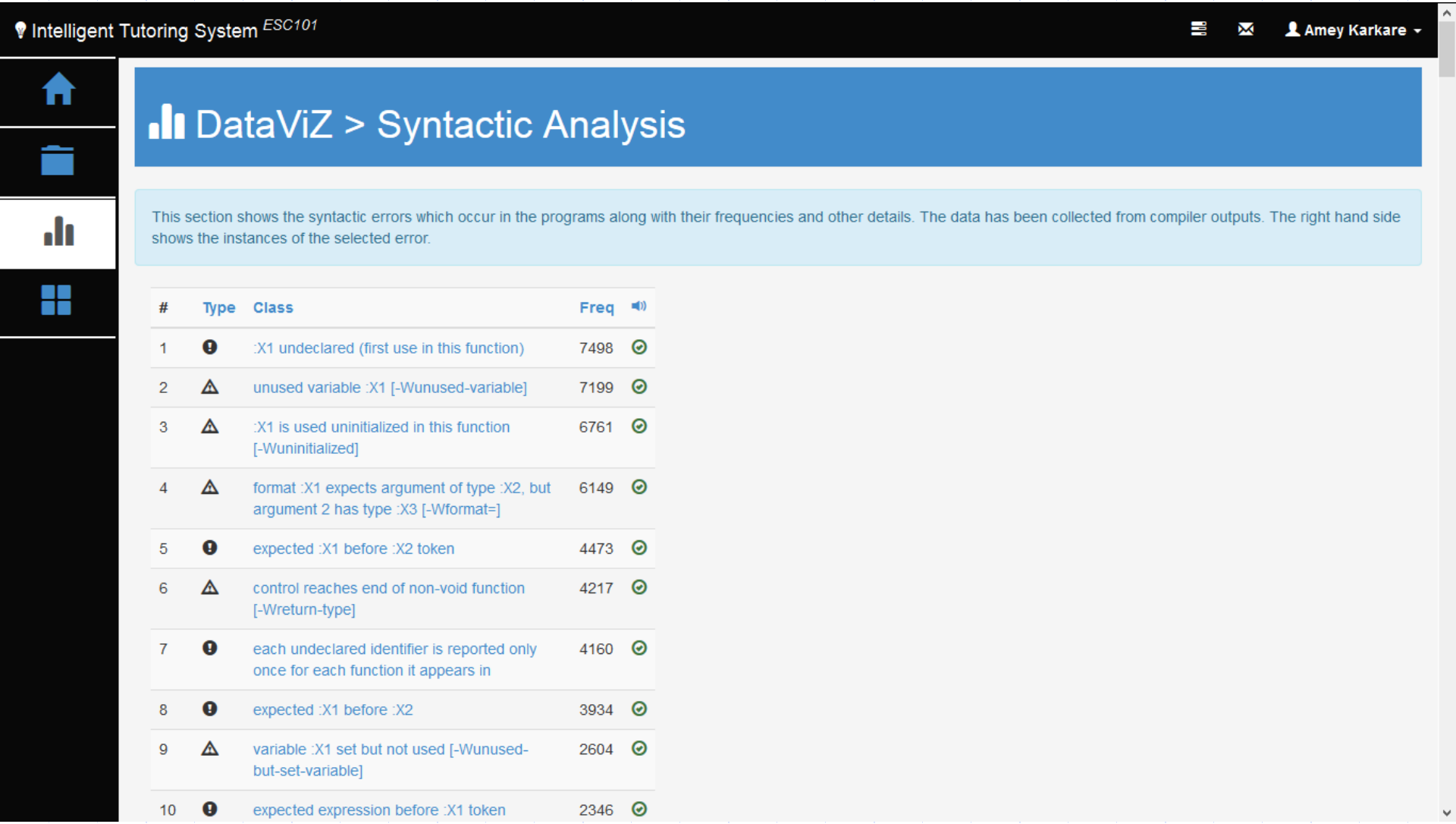


#	INPUT	OUTPUT	VISIBILITY
1	1	1	visible
2	5	2	visible
3	1080	6	visible
4	523456723	12	visible
5	6227020800	13	invisible
6	20922789888000	16	invisible

Control Panel and Settings



Analytics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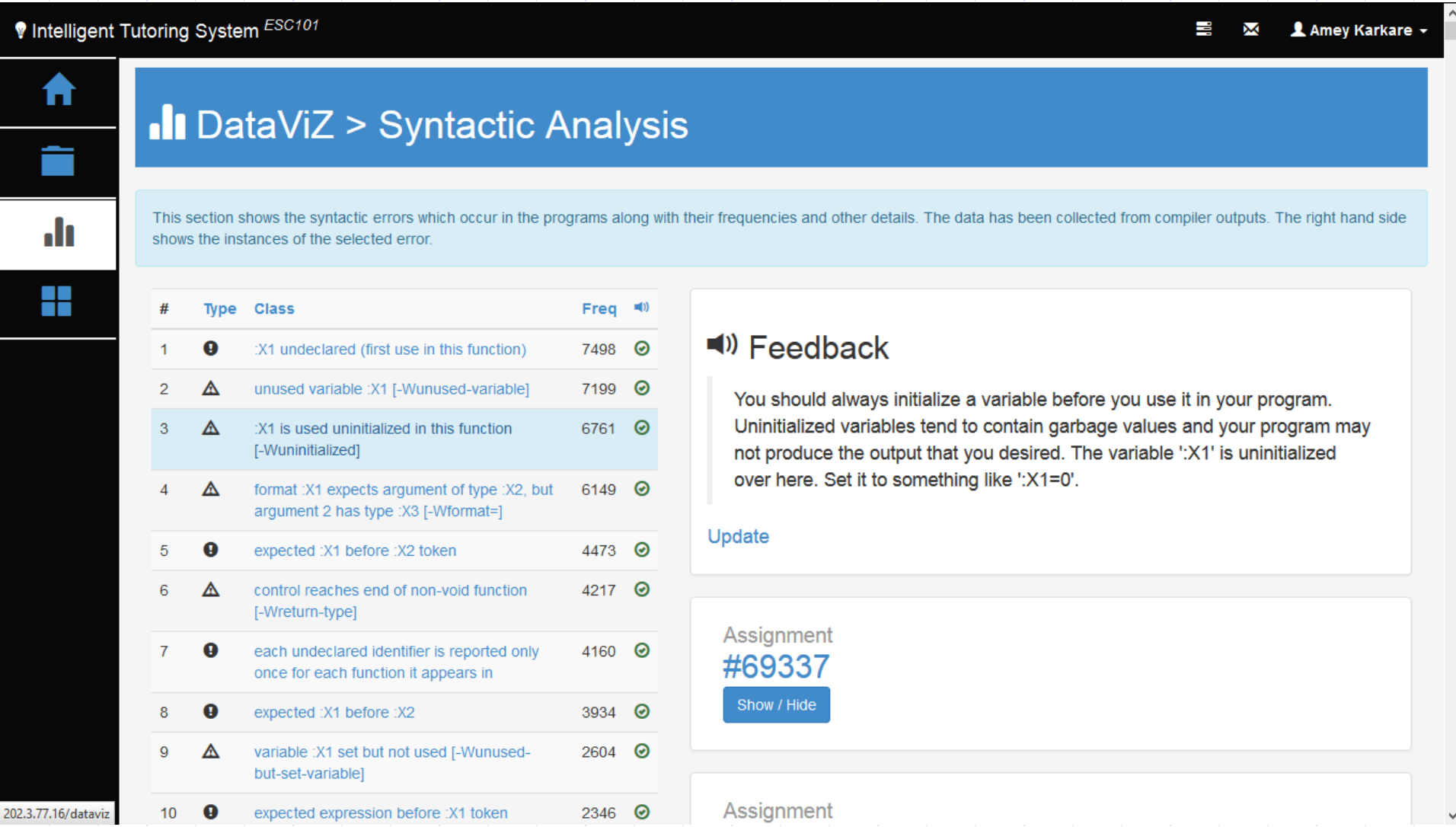
DataViZ > Syntactic Analysis
This section shows the syntactic errors which occur in the programs along with their frequencies and other details. The data has been collected from compiler outputs. The right hand side shows the instances of the selected error.
Type Class Freq
1 :X1 undeclared (first use in this function) 7498
2 unused variable :X1 [-Wunused-variable] 7199
3 :X1 is used uninitialized in this function [-Wuninitialized] 6761
4 format :X1 expects argument of type :X2, but argument 2 has type :X3 [-Wformat=] 6149
5 expected :X1 before :X2 token 4473
6 control reaches end of non-void function [-Wreturn-type] 4217
7 each undeclared identifier is reported only once for each function it appears in 4160
8 expected :X1 before :X2 3934
9 variable :X1 set but not used [-Wunused-but-set-variable] 2604
10 expected expression before :X1 token 2346

Syntactic Feedback



This section shows the syntactic errors which occur in the programs along with their frequencies and other details. The data has been collected from compiler outputs. The right hand side shows the instances of the selected error.

#	Type	Class	Freq
1	!	:X1 undeclared (first use in this function)	7498
2	⚠	unused variable :X1 [-Wunused-variable]	7199
3	⚠	:X1 is used uninitialized in this function [-Wuninitialized]	6761
4	⚠	format :X1 expects argument of type :X2, but argument 2 has type :X3 [-Wformat=]	6149
5	!	expected :X1 before :X2 token	4473
6	⚠	control reaches end of non-void function [-Wreturn-type]	4217
7	!	each undeclared identifier is reported only once for each function it appears in	4160
8	!	expected :X1 before :X2	3934
9	⚠	variable :X1 set but not used [-Wunused-but-set-variable]	2604
10	!	expected expression before :X1 token	2346
11	⚠	:X1 may be used uninitialized in this function [-Wmaybe-uninitialized]	2302
12	⚠	suggest parentheses around assignment used as truth value [-Wparentheses]	2124

Feedback

> You should always initialize a variable before you use it in your program. Uninitialized variables tend to contain garbage values and your program may not produce the output that you desired. The variable ':X1' is uninitialized over here. Set it to something like ':X1=0'.

Update

Assignment
#69337
Show / Hide

#2475434

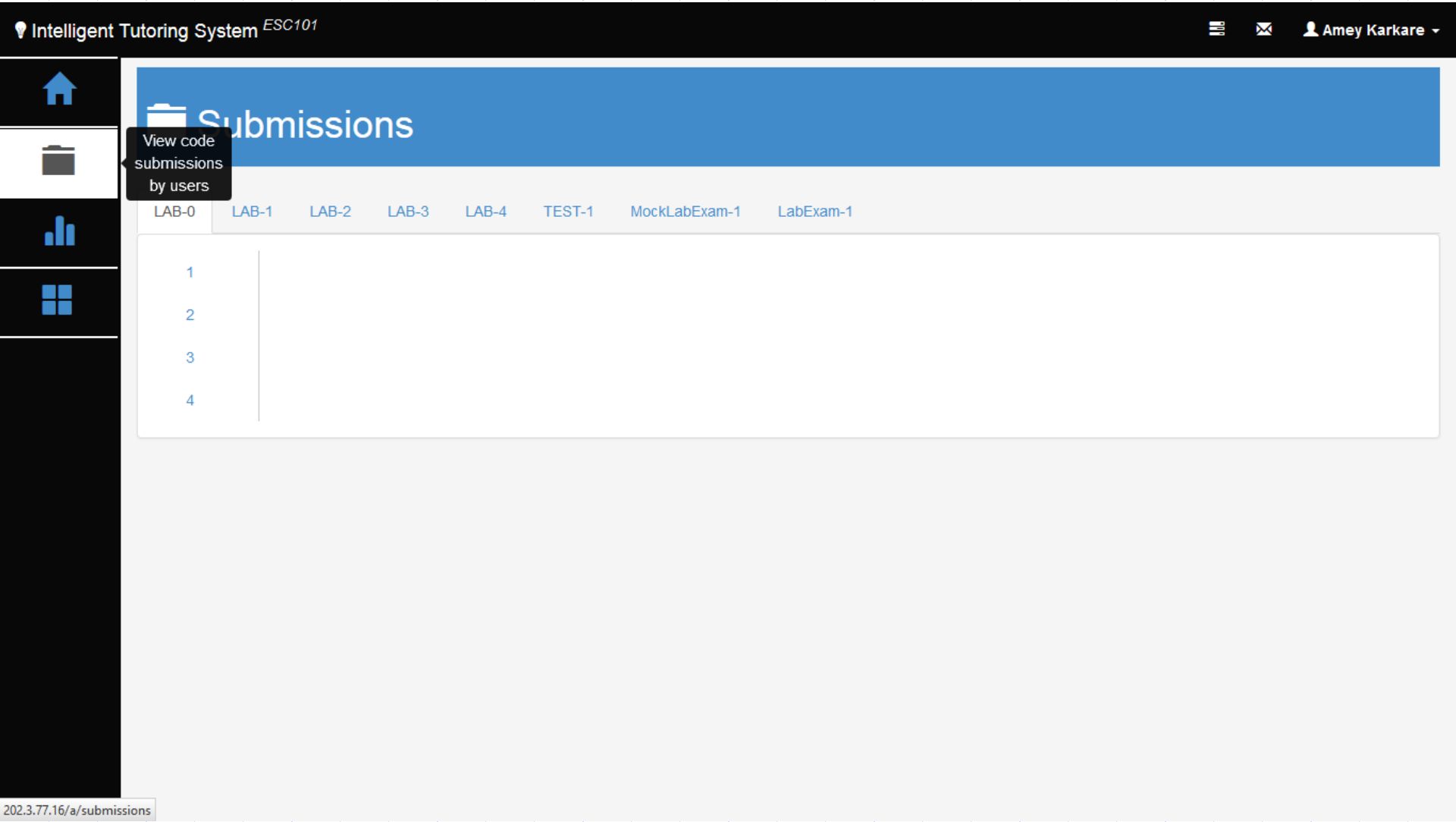
'a' is used uninitialized in this function [-Wuninitialized]

Assignment
#84401
Show / Hide

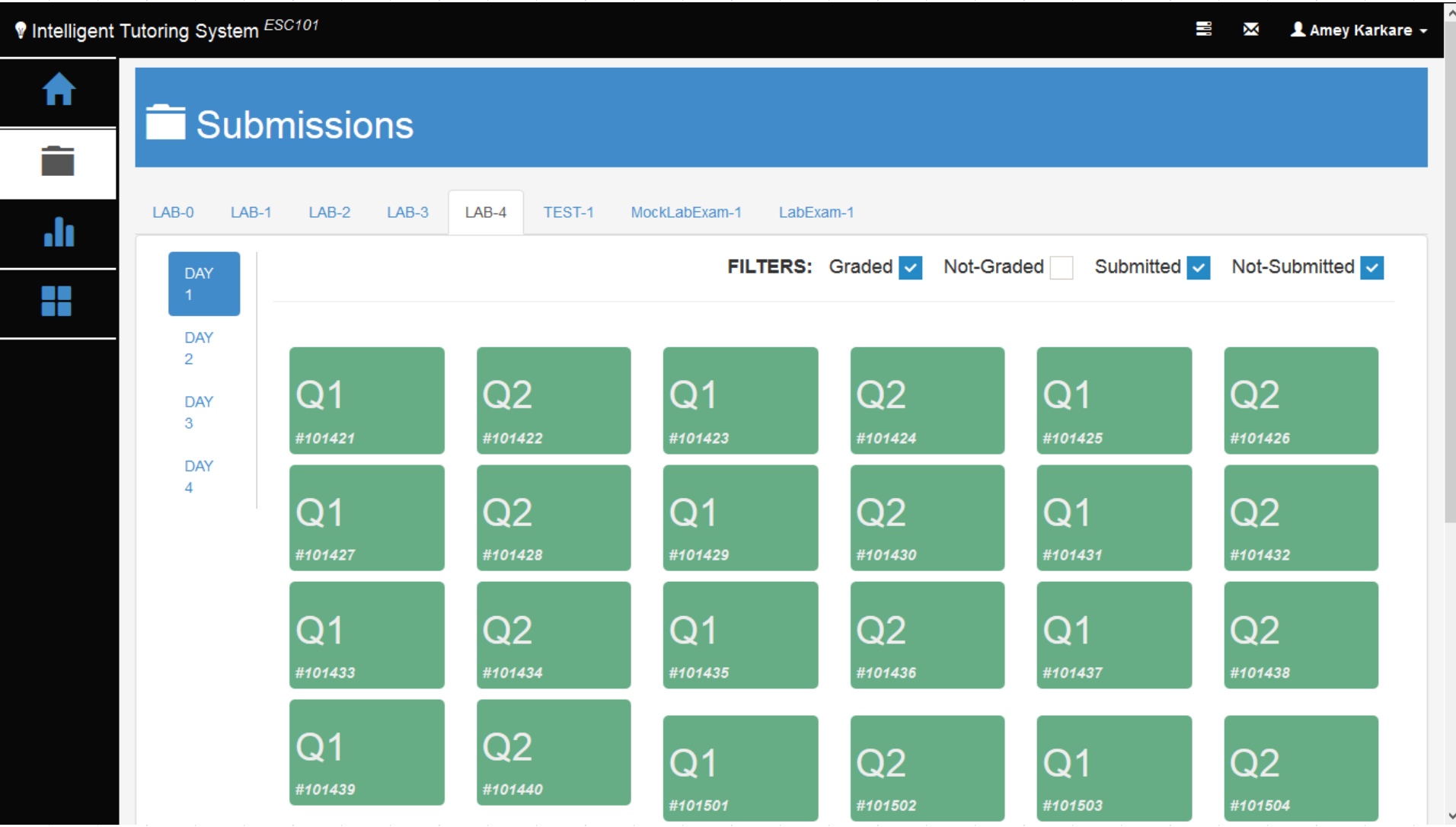
#2481649

'Celcius' is used uninitialized in this function [-Wuninitialized]

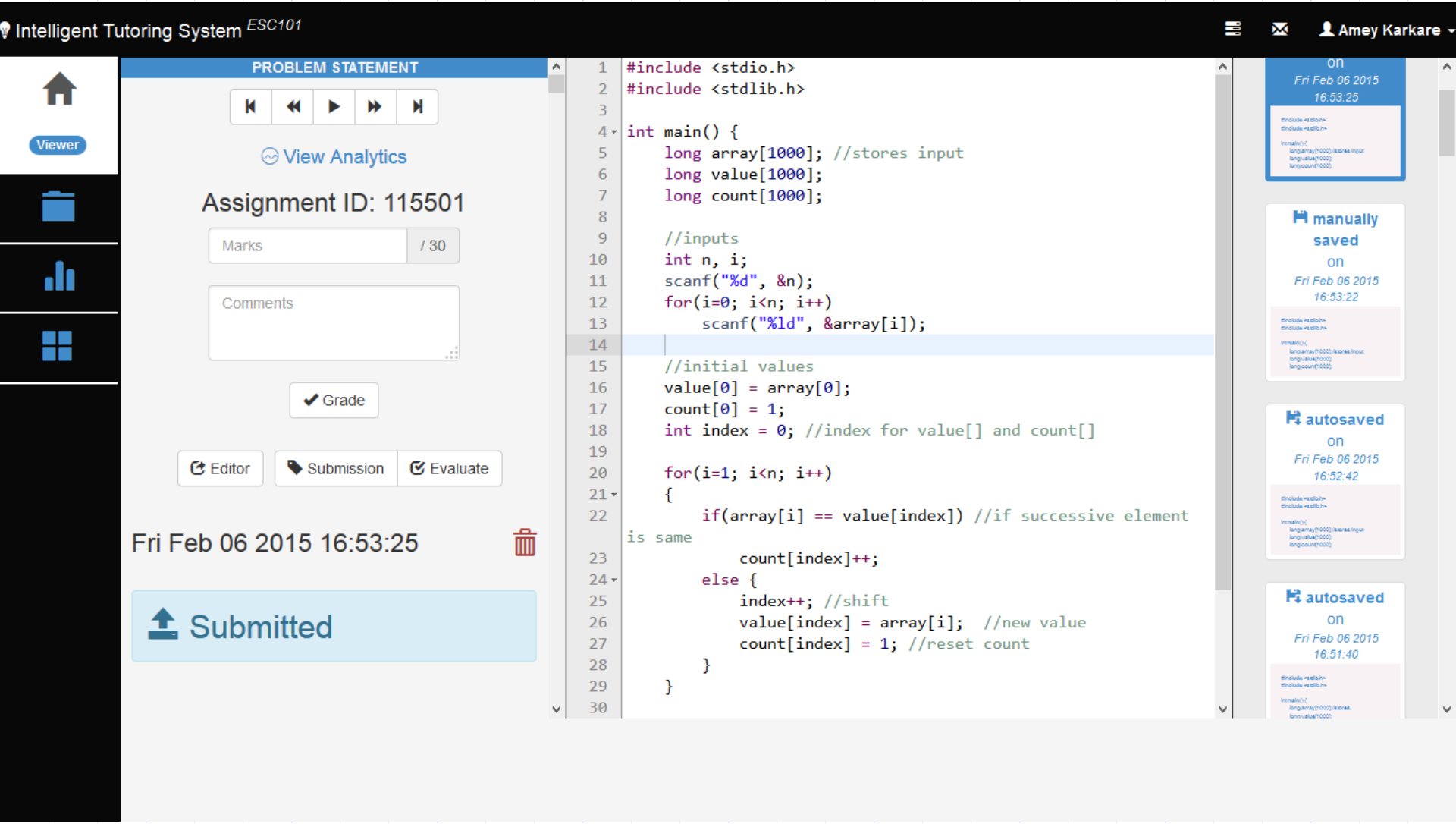
User Submissions



User Submissions



Grading Panel



Analytics per Submission

Intelligent Tutoring System *ESC101*

Amey Karkare

Assignment #115247

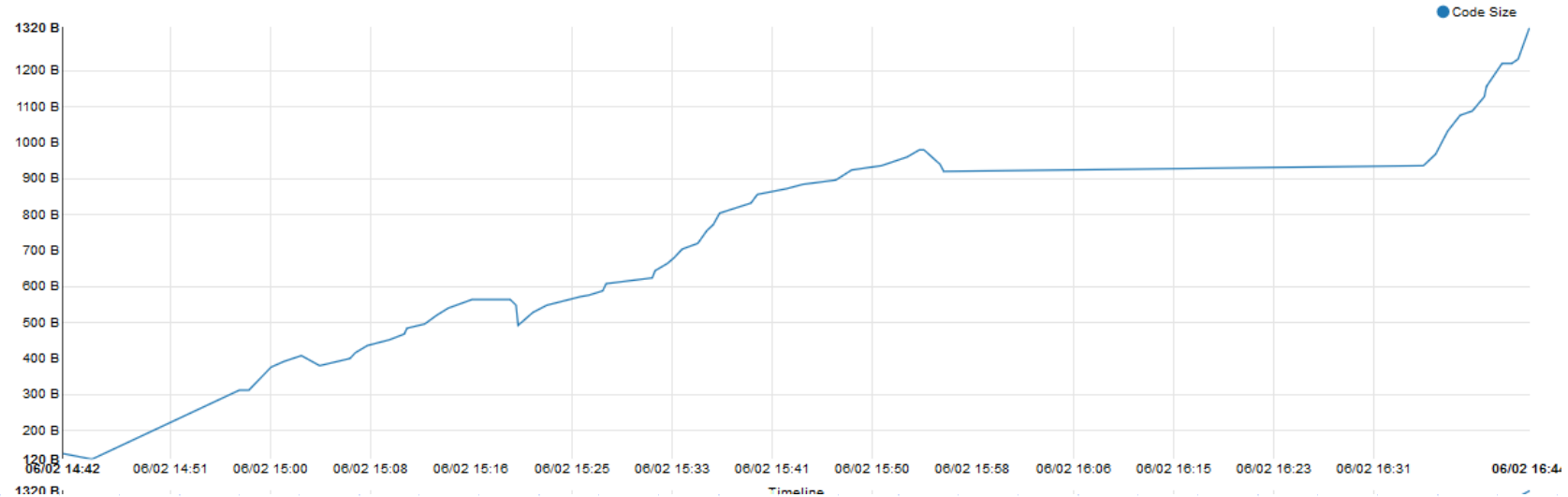
Analytics

Summary

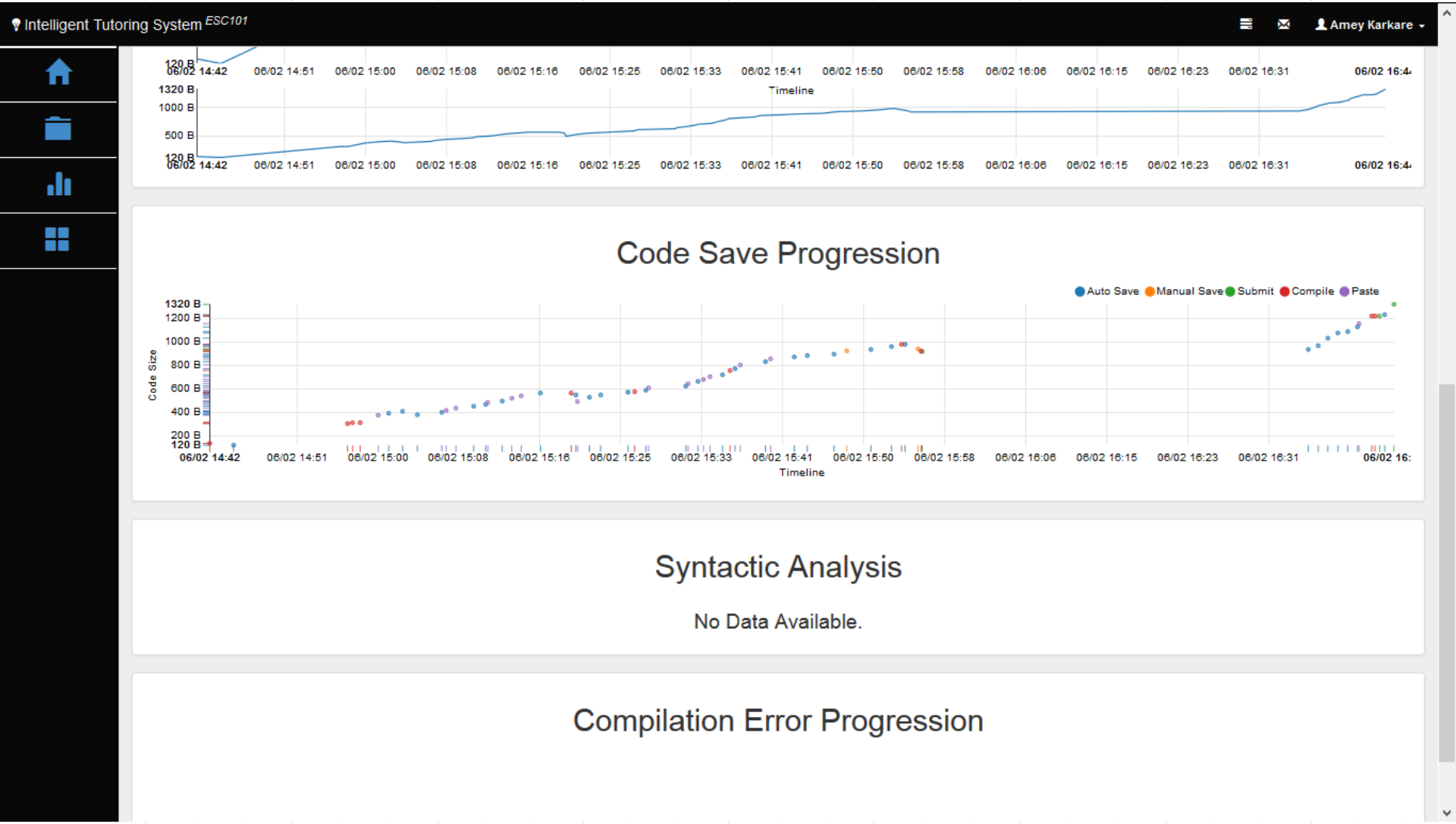
	Executions	Compilations	Submissions
#	1	0	3

Code Size Variation | Code Saves | Syntactic Analysis

Code Size Variation



Analytics per Submission

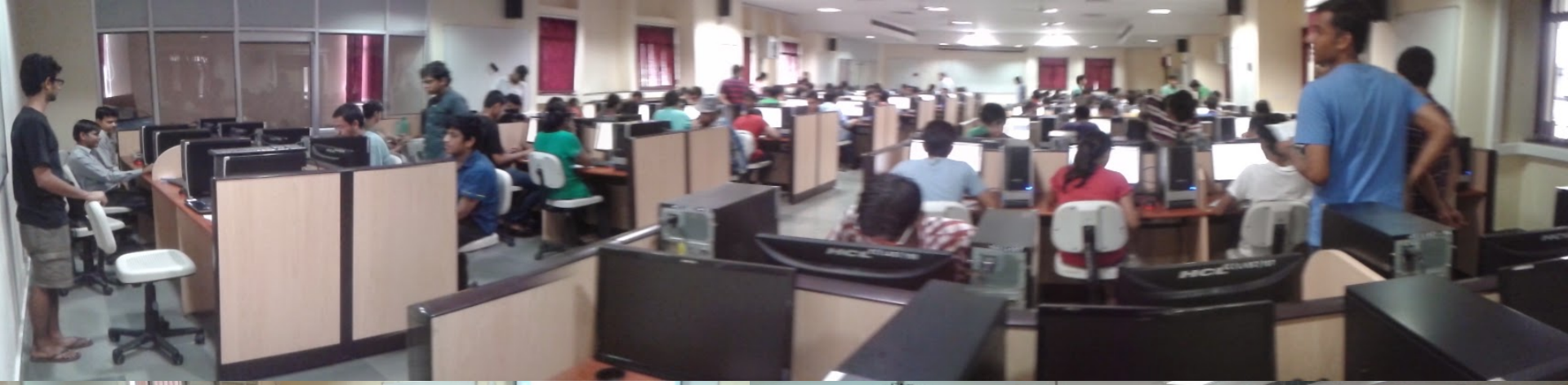


Concluding Remarks

- < 9 months old system, Still in experimentation phase
- Framework allows us to plug-and-play different components
  - Compiler: gcc, python, haskell
  - Feedback: Ivan's strategy based feedback, compiler message rewriting, some ad-hoc scripts
  - Automated Problem Generation: Ad-hoc programs
  - Automated Testcase Generation : KLEE

Future Work

- Lots of Data waiting to be processed
- Many HCI issues to be resolved
- Feedback tool has known limitations
  - Response time
  - False positives
  - Large # of specifications
- Crowdsourcing
  - test cases, peer review, specification generation, ...



Thank you.
Questions?

Some References

- Massively Empowered Classroom: Enhancing Technical Education in India (MSR-TR-2013-127)
- *Feedback Generation for Performance Problems in Introductory Programming Assignments*, FSE 2014, Sumit Gulwani, Ivan Radiček, Florian Zuleger
- KLEE: Unassisted and Automatic Generation of High-Coverage Tests for Complex Systems Programs, OSDI 2008, Cristian Cadar, Daniel Dunbar, Dawson Engler