Usability of error messages for introductory students

Paul Andrew Schliep

Division of Science and Mathematics
University of Minnesota, Morris
Morris, Minnesota, USA

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University of Minnesota, Morris

Introduction to error messages

- In programming, an error is when the computer cannot understand an expression in the code
  - these errors will return an error message
- Here's an example of an error message:

```
print("Hello World";
->java.3: error: unclosed string literal
```

Importance of error messages

- Error messages are important tool for beginner programmers
  - one of the primary interactions between the system and the user
- Unhelpful error messages impose learning difficulties, especially for new programmers
- Error messages with poor usability can lead the user down the wrong path

Goals of an error message

- An error message should:
  - not add confusion
  - be easy to understand
  - help a student locate the issue
- Example:

```
Developing...
```

Analyzing error messages

- Human-computer interaction: study on interfaces between user and programs
- Much of the research presented from an HCI perspective
- We will discuss error messages in terms of usability

Outline

Outline

Compiler errors

- When a compiler fails to compile a program, a user will receive a compiler error message
- For newer programmers, these typically occur from syntax errors
- Example (in Java):

```
int seven = (2 + 5;
error: ')' expected
```

Runtime errors

- A runtime error occurs after a program has compiled
- Usually indication of logical errors in the code
- Cannot be predicted, dependent on the values
- Example:

```
String string = "Hello World";
System.out.print(string.substring(6,12));

java.lang.StringIndexOutOfBoundsException:
String index out of range: 12
```

Statically typed

- All variables and/or objects assigned types
- Type checking done at compile time
  - this means different error messages
- Languages like Java or C++ are statically typed
- The following example would give an error at compile time in statically typed:

```
personName = "Frank"
personName = 7
```

Dynamically typed

- Values are not assigned to types
- Type checking done at runtime
- Languages in Lisp family
- The following example would give an error at runtime in dynamically typed:

```
personName = "Frank"
personName = 7
```

Outline

Racket programming language

- Programming language useful for teaching in introductory courses
- Member of Lisp languages
- Functional and dynamic language
- Syntax example:

```
(+ 1 2)
-> 3
```

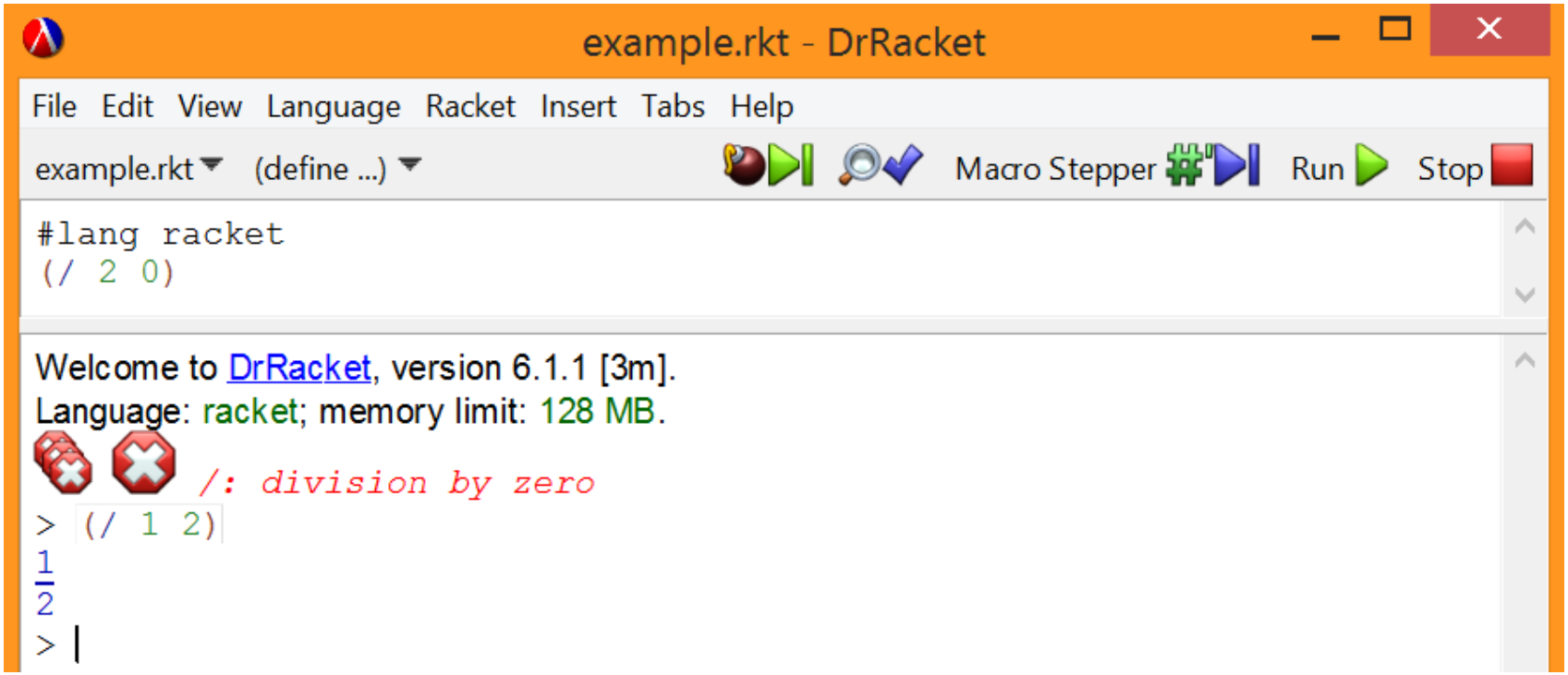
Integrated development environments

- An integrated development environment (IDE) is a program for writing and running code
- Some IDEs come packaged with debugging tools and custom error messages

DrRacket

- An IDE for developing programs in Racket
- Geared toward introductory programmers
- DrRacket offers (mostly) user-friendly error messages and libraries to program in various levels

DrRacket interface



Study of DrRacket error messages

- Marceau et al. interested in finding which errors students struggled with
- Configured DrRacket to save a copy of each program a student tried to execute and the error messages received
- Programs taken from a once-per-week lab session

Table of results

Lab Number	#1			#2			#3			#4			#5			#6		
	%error	%bad	#bad	%error	%bad	#bad	%error	%bad	#bad	%error	%bad	#bad	%error	%bad	#bad	%error	%bad	#bad
arg. count	5%	48%	0.22	17%	27%	**0.74**	14%	17%	0.33	13%	20%	0.24	35%	21%	**0.74**	12%	31%	0.36
parens matching	28%	24%	0.58	12%	14%	0.27	17%	0%	0.00	14%	0%	0.00	13%	0%	0.00	10%	15%	0.15
runtime cond	3%	0%	0.00	3%	100%	0.49	4%	20%	0.12	6%	72%	0.40	8%	78%	**0.62**	1%	100%	0.06
runtime type	2%	100%	0.15	8%	73%	**0.91**	16%	40%	**0.93**	8%	22%	0.17	6%	44%	0.26	3%	38%	0.13
syntax cond	14%	51%	0.59	4%	50%	0.31	6%	26%	0.24	10%	28%	0.25	9%	20%	0.17	11%	11%	0.12
syntax define	16%	50%	**0.68**	14%	50%	**1.14**	6%	15%	0.14	7%	24%	0.14	2%	17%	0.03	3%	38%	0.10
syntax func call	14%	64%	**0.74**	14%	17%	0.37	12%	14%	0.26	23%	27%	0.55	4%	29%	0.12	13%	38%	0.48
syntax struct	0%	0%	0.00	8%	32%	0.43	5%	92%	**0.73**	0%	0%	0.00	1%	0%	0.00	0%	0%	0.00
unbound id.	16%	16%	0.21	13%	40%	**0.85**	16%	14%	0.32	16%	0%	0.00	20%	7%	0.14	34%	13%	0.44

KEY:
%error: Percentage of error messages during lab of the given category of errors
%bad: Percentage of error messages that were poorly responded to
#bad: Estimate of the number of errors in the category that each student responded poorly to

Results

- Students struggle with certain errors relative to skill level
- Some errors were not indicator of underlying issue
  - student struggled with these errors
  - suggests issues in error message effectiveness

Student code example

```
(define (label-near? name bias word1 word2)
  (cond
      (and (cond [(string=? name word1)
                  "Name Located"]
                 [(string=? bias word2)
                  "Bias Located"])
           (cond [(string=? name word2)
                  "Name Located"]
                 [(string=? bias word2)
                  "Bias Located"])
      "Mark")
))
```

C++ programming language

- Something goes here...

Study and methods

- Something goes here...

Results

- Something goes here...

Outline

Introduction to recommendations

- Something goes here...

Recommendations

- Something goes here...

recommendations continued

- Something goes here...

conclusions and future work for program

- Something goes here...

Java and syntax errors

- Something goes here...

How they developed the program

- Something goes here...

How they tested the program

- Something goes here...

Results of syntax enhancement

- Something goes here...

Conclusions and future work of program

- Something goes here...

Outline

Results

- Something goes here...

Future work

- Something goes here...

Acknowledgments

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Thank you for your time and attention!

Contact:

- schli202@morris.umn.edu
- github.com/Paul-Schliep

Questions?

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See the GECCO '09 paper for additional references.