

Why Helping Struggling Beginning Programmers is Not an AI-Complete Problem

Christopher Riesbeck

Computer Science / Learning Sciences

Northwestern University

Acknowledgments

- **This material is based on work done on**
 - The DoD-funded AutoMentor Project for cybersecurity and Java training, with Allen Cypher, Wendy Lehnert, and Ray Bareiss at SocraticArts, Inc
 - An exploratory project with Chenghong Lin (CS MS) and Jeff Holm, using Piazza posts from CS 111 (Scheme/Racket) and CS 325

Learning Programming is Hard

- Many new terms, concepts, and mental models
- Small syntactic errors generate reams of cryptic error messages
- Bugs are fatal. Close is not good enough.
- Result: terrible retention, especially in large or online classes

```
> (beside (a-red-square)
          (a-blue-square)
          (a-green-square))

function call: expected a
function after the open
parenthesis, but received
#<image>
>
```

Learning Programming is Hard

- Many new terms, concepts, and mental models
- Small syntactic errors lead to reams of cryptic error messages
- Bugs are fatal. Clojure is not enough.

```
> (beside (a-red-square)
          (a-blue-square)
          (a-green-square))

function call: expected a
function after the open
parenthesis, but received
```

```
2018-06-19 12:56:45.670 WARN 14588 --- [ main] ationConfigEmbeddedWebApplicationContext :
Exception
encountered during context initialization - cancelling refresh attempt:
org.springframework.beans.factory.BeanCreationException: Error creating bean with name
'entityManagerFactory' defined in class path resource
[org/springframework/boot/autoconfigure/orm/jpa/HibernateJpaAutoConfiguration.class]:
Invocation of
init method failed; nested exception is org.hibernate.AnnotationException: mappedBy reference
an
unknown target entity property: salvo.salvo.Score.gamePlayer in salvo.salvo.GamePlayer.scores
2018-06-19 12:56:45.674 INFO 14588 --- [ main] o.apache.catalina.core.StandardService :
Stopping
service [Tomcat] 2018-06-19 12:56:45.688 INFO 14588 --- [ main]
utoConfigurationReportLoggingInitializer : Error starting ApplicationContext. To display the
auto-configuration report re-run your application with 'debug' enabled. 2018-06-19 12:56:45.698
ERROR 14588 --- [ main] o.s.boot.SpringApplication : Application startup failed
org.springframework.beans.factory.BeanCreationException: Error creating bean with name
'entityManagerFactory' defined in class path resource
```

Helping is Hard

- Need to be an expert in both programming and pedagogy
- What students say is happening is rarely correct, often not even coherent

How can I make the undefined predicate return true/false in the definition? If the predicate is 'general', which means the exact procedure of predicate will be provided outside of the definition, how could we use the conditional statement (when/unless/if/cond) in the definition?

I was trying to upload it from winscp, but it was saying error. What should my home directory say, I'm not sure what directory it was trying

Helping is Hard

- Need to be an expert in both programming and pedagogy
- What students say is happening is rarely correct, often not even coherent

How can I make the undefined predicate return true/false in the definition? If the predicate is 'general' which means the exact

At this point, I am only attempting to get the signup portion working. I have not even attempted to get the login and the log out working, but there is some code in there for them. The HTML and controller code is the same for both. Each attempt has a different issue. Attempt 1: In this attempt, when I try to signup, I am immediately going to the fail condition of ms js ajax call. I am getting back a 404 error and an alert that says Error: error Attempt 2: When I try to sign up, I am redirected to the login screen that is generated by Spring (I think). We have added /api/players to my antmatchers, so I am not really sure what is happening. Charity also showed me this example that she found, which I am trying to follow: <http://codippa.com/how-to-send-form-data-to-spring-controller-using-ajax-how-to-submit-form-using-ajax/> Although, it has not helped me solve my problem, I am finding it a little easier to follow since it shows examples of the HTML, js, and controller code all in one place, and all for the same example. I think this is lacking in the current resources for the class. Could you please look at this and help me (and Charity) to see what is going wrong, and also which attempt is closer to what you are looking for. I have already spent ~25 hours on this part of the Task alone. :-(

Helping is Labor-Intensive

- One-on-one, collaborative sessions
- Problem-solving, designing, debugging, mini-tutorials
- Sessions run from 15 minutes to an hour
- This is challenging to scale...
- ... and may be misdirected.

The professor and TAs were so helpful!

Honestly, I couldn't have made it through the course without them.

The professor was absolutely useless!

I had to teach myself HTML, I had to teach myself CSS, I had to teach myself JavaScript.

Which student is likely to be more prepared for the future?

Three Rules for Better Mentoring

- Ignore what students say.
- Don't solve their problems.
- Don't give personalized advice.

“Show me what you did.”

Redirect them to the resources they can use to solve it themselves.

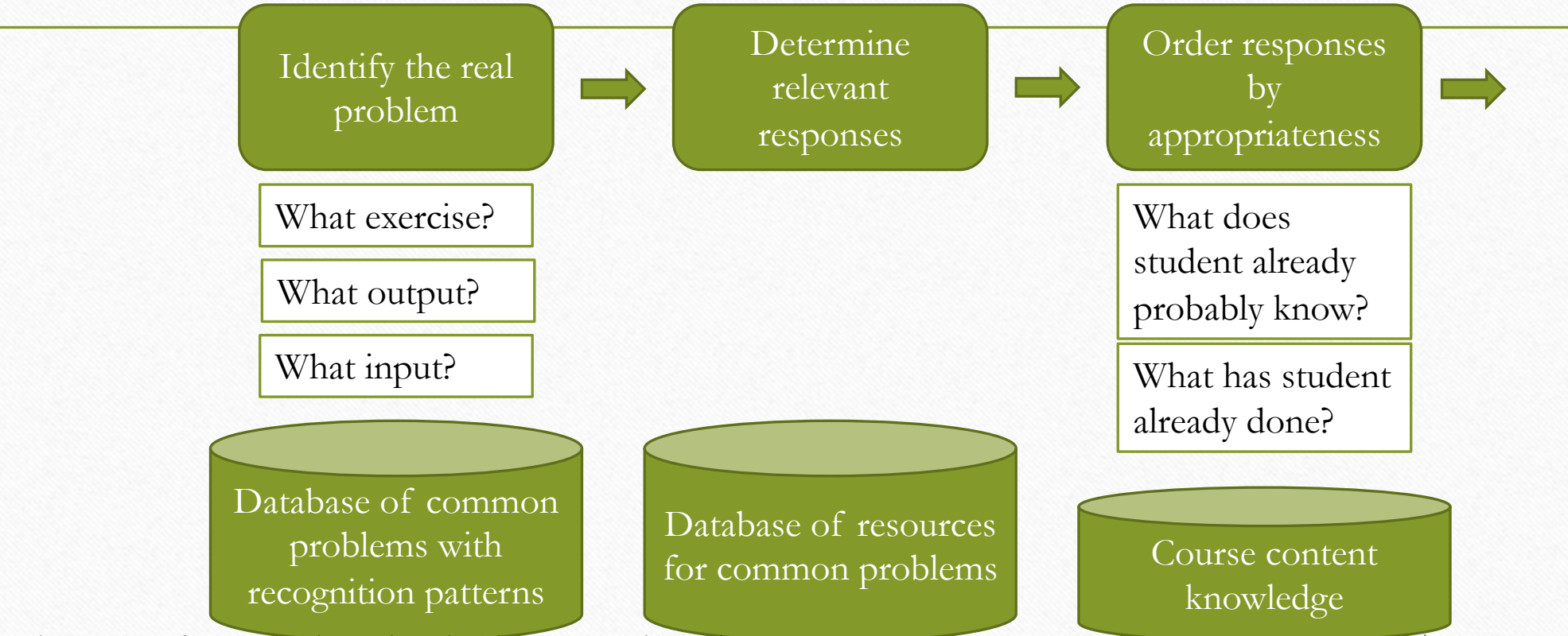
A model for scalable quality mentoring

- Diagnose problem based on reliable inputs:
 - Source code, computational output, exercise requirements
- Redirect to resources relevant to the problem, and appropriate for the student.

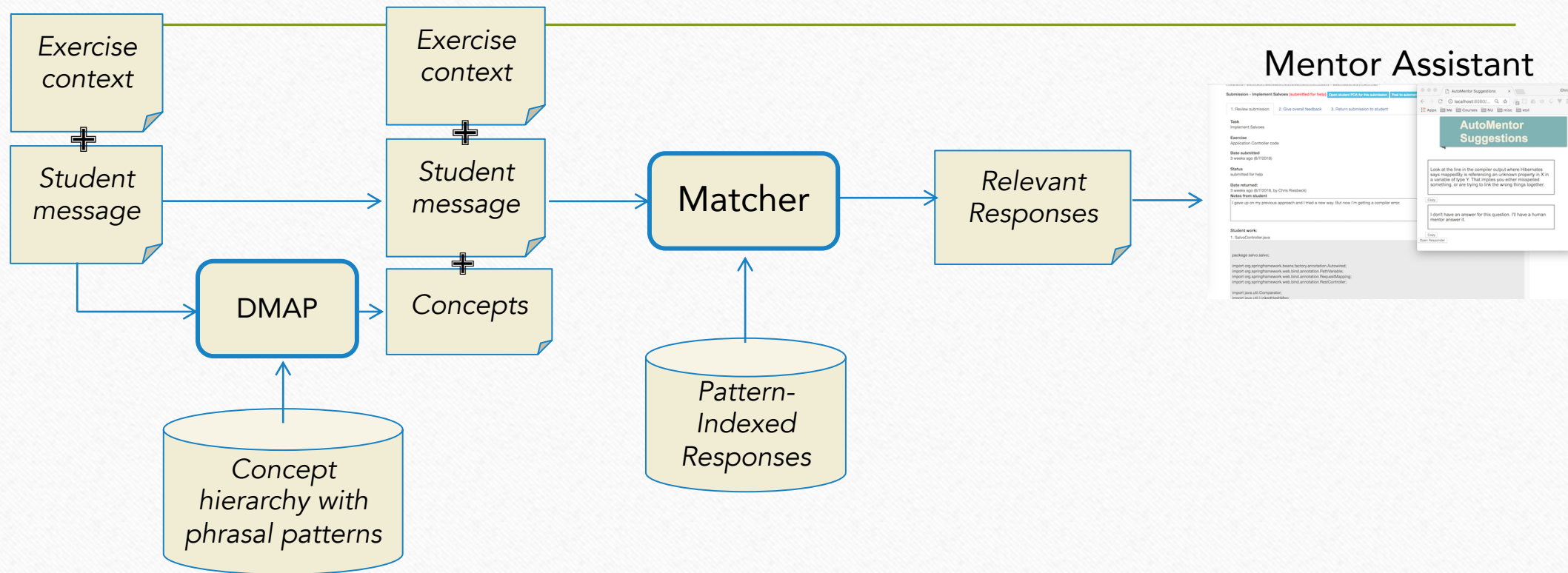
An AI-Friendly Model

- No serious natural language understanding needed.
- No serious natural language generation needed.
- Naturally occurring highly constraining features easily available:
 - Course timeline of topics, specifications of current exercise
- Not compromising the ultimate goals of mentoring.

Assisted Mentoring



AutoMentor Architecture



Pattern-Based Diagnosis

```
2018-06-19 12:56:45.670 WARN 14588 --- [ main]
ationConfigEmbeddedWebApplicationContext : Exception
encountered during context initialization - cancelling refresh
attempt:
org.springframework.beans.factory.BeanCreationException: Error
creating bean with name
'entityManagerFactory' defined in class path resource
[org/springframework/boot/autoconfigure/orm/jpa/HibernateJpaAutoConfig
uration.class] failed; nested exception is
org.hibernate.AnnotationException: mappedBy reference an
unknown target entity property: salvo.salvo.Score.gamePlayer in
salvo.salvo.GamePlayer.scores
2018-06-19 12:56:45.674 INFO 14588 --- [ main]
o.apache.catalina.core.StandardService : Stopping
service [Tomcat] 2018-06-19 12:56:45.688 INFO 14588 --- [ main]
utoConfigurationReportLoggingInitializer : Error starting
ApplicationContext. To display the
auto-configuration report re-run your application with 'debug'
enabled. 2018-06-19 12:56:45.698
ERROR 14588 --- [ main] o.s.boot.SpringApplication : Application
startup failed
org.springframework.beans.factory.BeanCreationException: Error
creating bean with name
'entityManagerFactory' defined in class path resource
[org/springframework/boot/autoconfigure/orm/jpa/HibernateJpaAuto:
Invocation
```

Northwestern Center for Computer Science and Learning Sciences – Inaugural Symposium

Problem: missing entity annotation

Pattern: /mappedBy reference an unknown target/

Relevant resources:

["Java entities"]

["example entity definition"]

["working example of application with entity"]

["interpreting Java compiler errors"]

["Hibernate error messages"]

Identifying what students know

- **Where are they in the course?**
- **How advanced is the exercise?**
- **What do they seem to understand about their problem?**
 - I fibbed. You don't totally ignore what they say.



Identifying what students know

I am still having trouble with this step. Charity and I spent 3 hours on the phone last night trying to work through this. She has it working using path variables, but the POA asks for ResponseEntities. I am sending you two different attempts that we made. At this point, I am only attempting to get the signup portion working. I have not even attempted to get the login and the log out working, but there is some code in there for them. The HTML and controller code is the same for both. Each attempt has a different issue. Attempt 1: In this attempt, when I try to signup, I am immediately going to the fail condition of ms js ajax call. I am getting back a 404 error and an alert that says Error: error Attempt 2: When I try to sign up, I am redirected to the login screen that is generated by Spring (I think). We have added /api/players to my antmatchers, so I am not really sure what is happening. Charity also showed me this example that she found, which I am trying to follow: <http://codippa.com/how-to-send-form-data-to-spring-controller-using-ajax-how-to-submit-form-using-ajax/> Although, it has not helped me solve my problem, I am finding it a little easier to follow since it shows examples of the HTML, js, and controller code all in one place, and all for the same example. I think this is lacking in the current resources for the class. Could you please look at this and help me (and Charity) to see what is going wrong, and also which attempt is closer to what you are looking for. I have already spent ~25 hours on this part of the Task alone. :-(

I am still having trouble with this step. Charity and I spent 3 hours on the phone last night trying to work through this. She has it working using **path variables**, but the POA asks for **ResponseEntities**. I am sending you two different attempts that we made. At this point, I am only attempting to get the signup portion working. I have not even attempted to get the login and the log out working, but there is some code in there for them. The **HTML** and **controller** code is the same for both. Each attempt has a different issue. Attempt 1: In this attempt, when I try to signup, I am immediately going to the fail condition of ms js **ajax call**. I am getting back a **404 error** and **an alert that says Error: error** Attempt 2: When I try to sign up, I am **redirected** to the login screen that is generated by **Spring** (I think). We have added /api/players to my **antmatchers**, so I am not really sure what is happening. Charity also showed me this example that she found, which I am trying to follow: <http://codippa.com/how-to-send-form-data-to-spring-controller-using-ajax-how-to-submit-form-using-ajax/> Although, it has not helped me solve my problem, I am finding it a little easier to follow since it shows examples of the HTML, js, and controller code all in one place, and all for the same example. I think this is lacking in the current resources for the class. Could you please look at this and help me (and Charity) to see what is going wrong, and also which attempt is closer to what you are looking for. I have already spent ~25 hours on this part of the Task alone. :-(

The AI in AutoMentor

- AutoMentor uses classic symbolic AI:
 - Concept hierarchies, pattern matching, memory-based language understanding (DMAP)
 - Can be understood and refined by human mentors
 - Can be developed from very small initial sample sets
- Statistical Natural Language Processing and Machine Learning Methods
 - Require thousands of exemplars
 - Good for tune content selection methods once mentoring has reached Internet scale

Assisted Mentoring: Scale And Quality

- **For students:**
 - Greater autonomy
 - Practice all skills: coding, debugging, active reading, resource search, algorithm design
 - Avoid mentor dependence.
- **For mentors:**
 - Less effort, higher quality, more consistent