

A system for Natural Language Question Answering for Self-Paced K-12 Learning

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Introduction

Question-asking is an important part of learning in class. However, many students cannot ask questions when they are:

- Learning at home
- Learning from adaptive learning platforms

Even in class, many students may have different questions at the same time. The teacher cannot answer all questions at the same time.

A Possible Solution

Automated question answering systems in education (Louwerse et al., 2002; Corbett et al., 2005; Milik et al., 2006; Jin et al., 2018)

Systems where students can ask questions in natural language... and receive a meaningful answer!

Different than simply a search engine:
Provide answers relevant to current *content* and *grade* level

Past demonstration projects...
Limited effort to scale these systems

Challenges

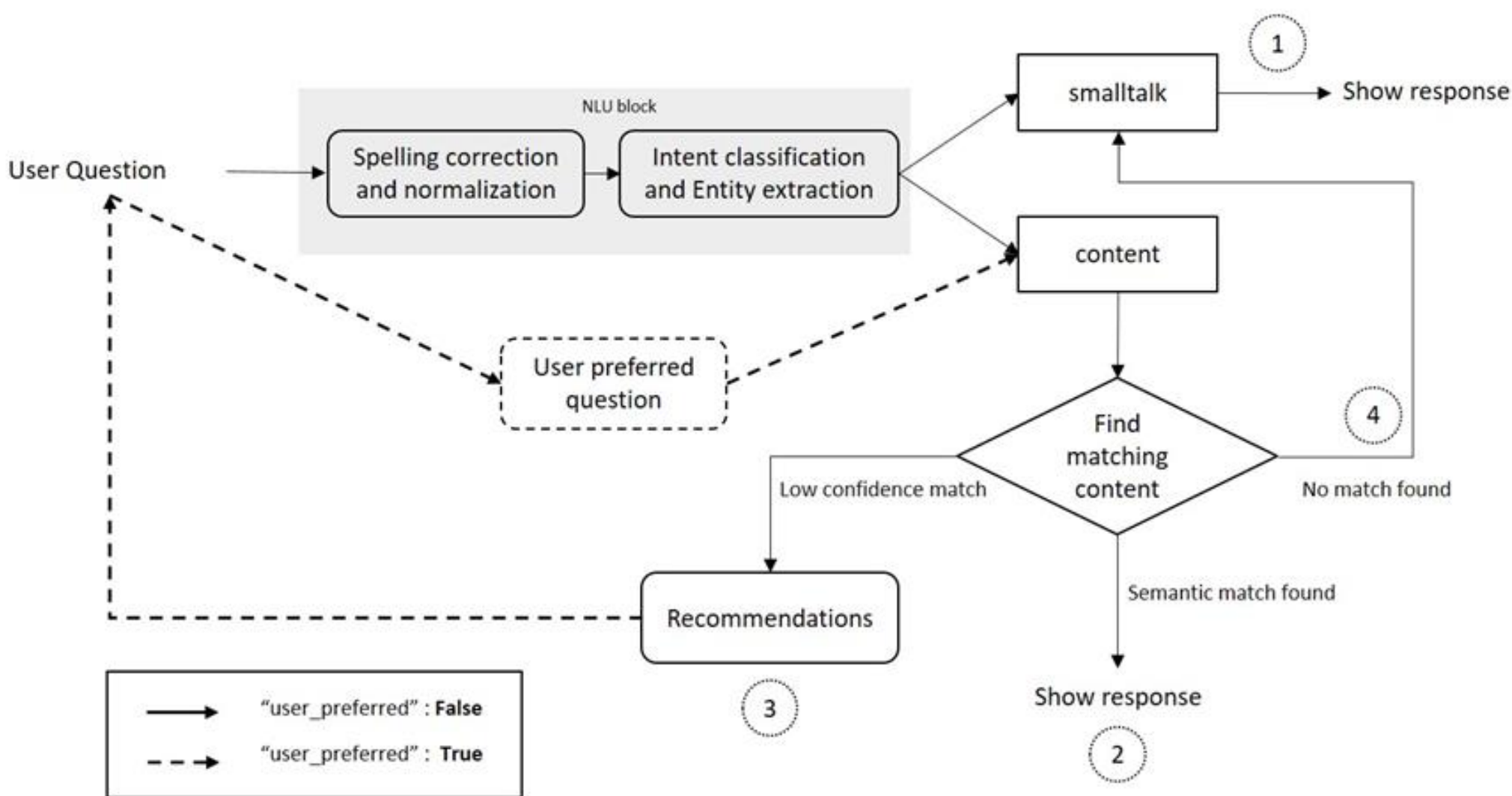
- Unforeseen queries
- Variability in language
- Filter off-topic and social utterances
- Handle grammatical and spelling errors
- Map ill-formed questions to appropriate content
- Provide resources at appropriate grade level



CURIO SmartChat

A system for self-paced K-12 learning through asking questions

First domain: middle school Science
~20,000 students have asked ~100,000 questions



Architecture of QA engine

Content Library

Includes a compilation of text documents and quick definitions collected based on the curriculum.

Also includes questions and answers tagged to:

- Knowledge: Includes definitions, requires no prerequisites
- Understanding: Relates course knowledge to other information
- Application: Test understanding as it relates to practical scenarios

QA Engine

When the user asks a question:

1. Engine *corrects* and *normalizes* simple spelling and grammar errors, to focus on science content
2. Contractions are resolved (i.e. “What’s energy?” → “What is energy?”)
3. System infers if question is related to content, or if it is *smalltalk* (uses custom taggers we have developed, extending SpaCy taggers)
4. If query assessed to be content-related, system attempts to retrieve answer from content library through a combination of semantic matches
 - * using Vector Space approach
 - * addresses polysemy through deep bidirectional language model
 - * uses sentence-level encoders, using Google’s Universal Sentence Encoder to detect paraphrases
 - * hash table lookup also used for common queries
 - * multiple recommendations offered if none have sufficient confidence

Analysis 1: Quality of Recommendations

Two human raters independent rated quality of 200 randomly selected student queries/system responses

A set of responses was coded as **valid** if at least one of the four responses provided was considered an appropriate response to the query.

The coders also assessed whether there was content in the system that would be appropriate for the query

Content Available	Count	Percent of recommendations considered valid (Rater 1)	Percent of recommendations considered valid (Rater 2)
No	28	0.70 (19)	0.64 (18)
Yes	107	0.55 (59)	0.73 (78)
Query not clear	65	0.49 (31)	0.47 (29)
Count	200	0.55	0.63

Analysis 2: Spelling Mistakes

Category	User Query
Insertion	you are from e wich contry; can you tell me what acide e are the produce; what is nonpoar molecule ns
Omission	what is mixtu r ; wate e is a substnsce with a sour taste; wa t is meen saturated solution
Substitution	what are the eyeglasses called that hab e both concave and convex lenses; ya s i needd halp
Inversion	waht is meen pressure; waht maen acid ph
Duplication	can u tell me about defin nn ing solubility? wich termes de escribe a substance that has an equal amount of hydronium and hydroxide ions
Phonetic Errors (most common, particular h)	but i don't find the an ser ; Hi. Wat your name; were you are

Analysis 3: Small Talk

Curio has a small library of *smalltalk* responses – when a student provides an off-topic utterance, one of this library is chosen. About 1/3 of student utterances are on-topic.

The system defaults to “Please ask me about middle school topics in Science.” when the student spends too long (too many utterances) in small talk, or provides an off-topic utterance that the system cannot match to a response. 23% of students return to on-topic questions after receiving this default utterance.

User 3 says	Curio responds
I am nicer than u	I would have to agree.
U should agree	I guess I can appreciate that.
no ur not ya we r	Are we debating?
b bbbbdjv cvmnsnv vdklv sd ,bvfheeubr h	Please ask me about middle school topics in Science.
	Please ask me about middle school topics in Science.

User 1 says	Curio responds
What is a mammal?	Mammals are animals that give birth to babies rather than laying eggs and feed their young with milk. Examples of mammals include human beings, dogs, whales and bears.
What is an animal?	An animal is a living organism that feeds on organic matter. It typically has specialized sense organs and a nervous system, which makes it able to respond rapidly to stimuli.
I want to just chill	Please ask me about middle school topics in Science.
fine	Okay.
can you explain bird	A bird is a warm-blooded vertebrate with feathers.

User 2 says	Curio responds
Dim	Dim means not shining brightly or clearly.
good	Let's just try again, we'll get it right eventually.
:(! You are not too nice.
i mean :)	Never mind. Just kidding.
what does meiosis mean	The chromosome number is halved from diploid to haploid, resulting in genetically different cells. This process of reduction division is called meiosis.