CAPITAL Words: Algorithmic Generation of Reading and Spelling Exercises for Low-Literacy Users

Katherine Stasaski, Elsbeth Turcan, Jennifer Hill, and Rahul Simha
The George Washington University, Department of Computer Science

THE GEORGE WASHINGTON UNIVERSITY · WASHINGTON, DC

School of Engineering & Applied Science · THE GEORGE WASHINGTON UNIVERSITY

Introduction

According to the American Library Association, 14% of United States adults cannot "search, comprehend, and use continuous texts" [1], and these individuals receive only limited government assistance. Additionally, smartphone users account for 52% of Americans with less than a high school education [2], making mobile applications an ideal way to reach these students.

Therefore, we present CAPITAL, a mobile software suite designed to make high-quality learning resources available to users of all level literacy skill. In particular, we target native English-speaking adults at the most basic levels of literacy.

Interface Design

Since CAPITAL Words' target audience is low-literacy users, the software must be designed with them in mind, avoiding using many words when possible.

We endeavored to avoid branching menus and screens full of words and to make the app as intuitive as possible. For example, pictures rather than words are used to represent components like courses, and the flow through the system is highly linear.

We performed a usability study with 11 adult learners, 4 of whom had never used a smartphone, and nearly 100% of them were able to perform all core tasks in the app with at most one error.

Back-End Resources

The CAPITAL system comprises an instructor website, where instructors generate and customize learning materials, and a student application, where students practice them. Exercises are generated through the website, which stores its data in a MySQL database and uses several resources to make intelligent decisions about individual words:

- The **Google dictionary**, for audio pronunciations, and **Google Text-to-Speech**, for non-dictionary words
- The **CMU Pronouncing Dictionary**, for the breakdown of a word into its component phonemes
- The **Moby Hyphenator**, for the hyphenation of words, which often corresponds to their syllable breakdown

Algorithms

We developed three distinct types of exercises to test different literacy-related skills.
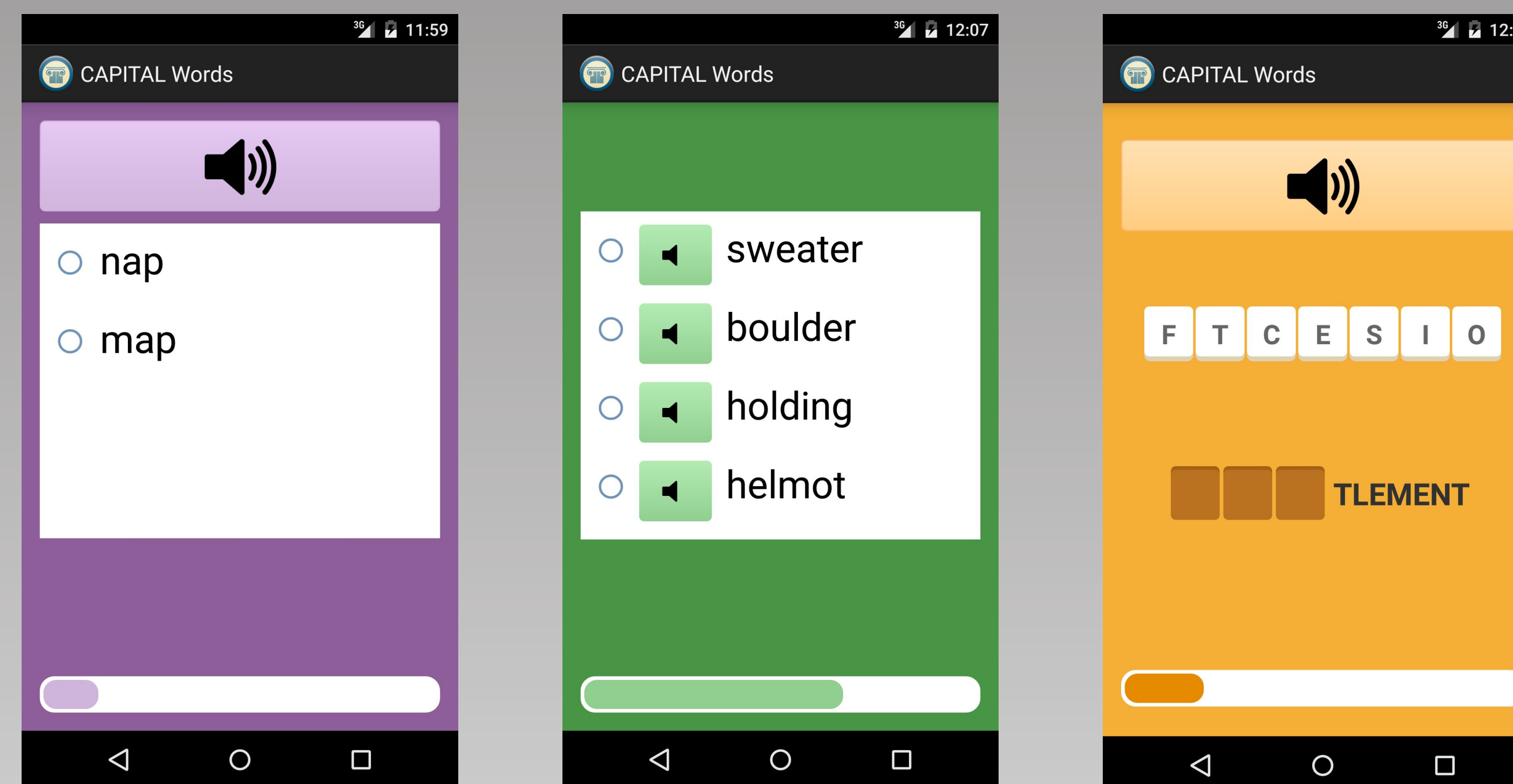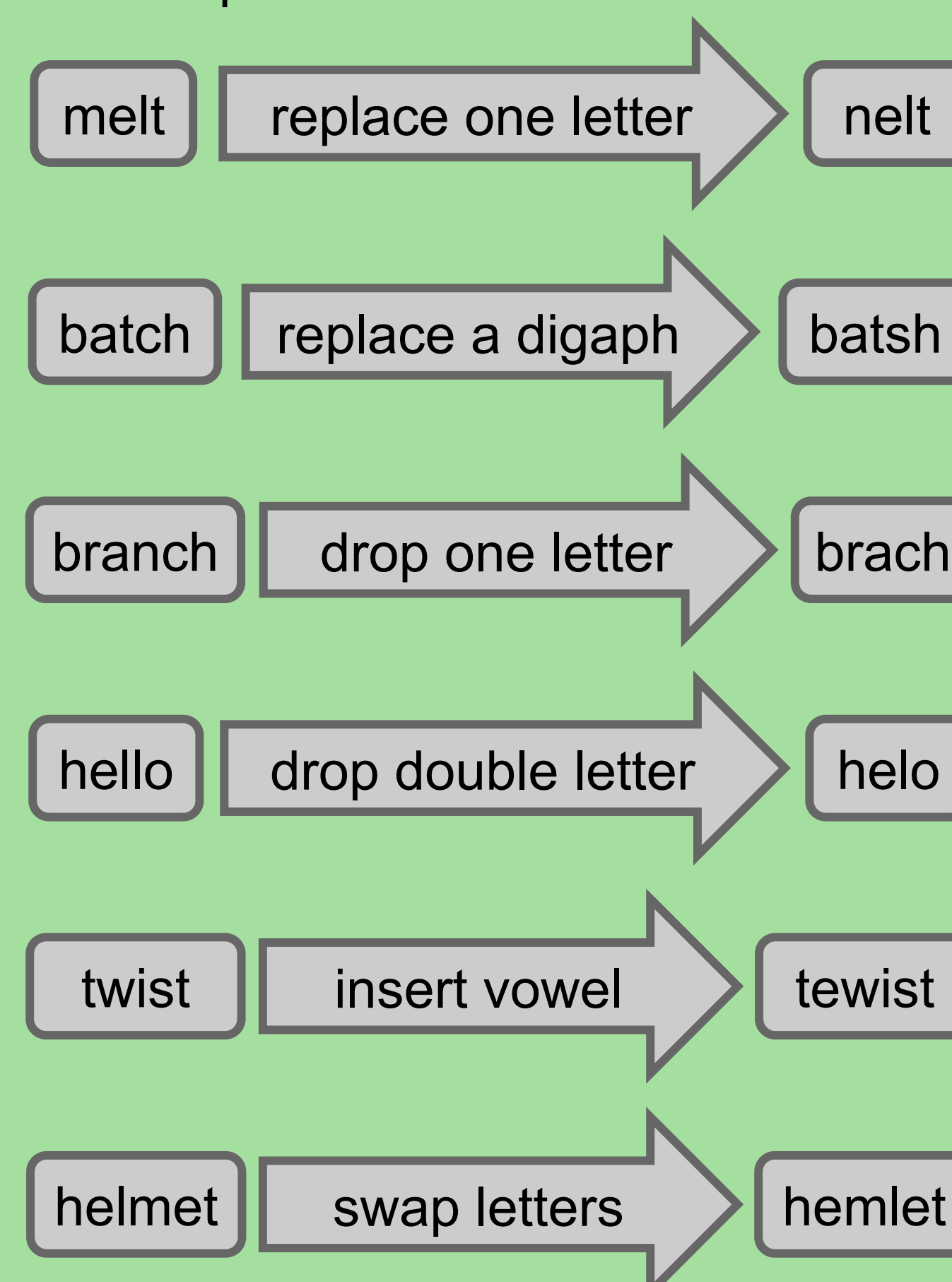

Phoneme Swap

- Multiple-choice questions where students either hear a word spoken and choose its correct spelling, or see a word written and choose its correct pronunciation
- Choose words that differ by only one phoneme and select foils for a base word using commonly-confused letters

P [AE] N — pan
P [IH] N — pin
P [AY] N — pine

nap — [N][AE][P]
map — [M][AE][P]

K [AA] F — cough
K [AE] F — calf
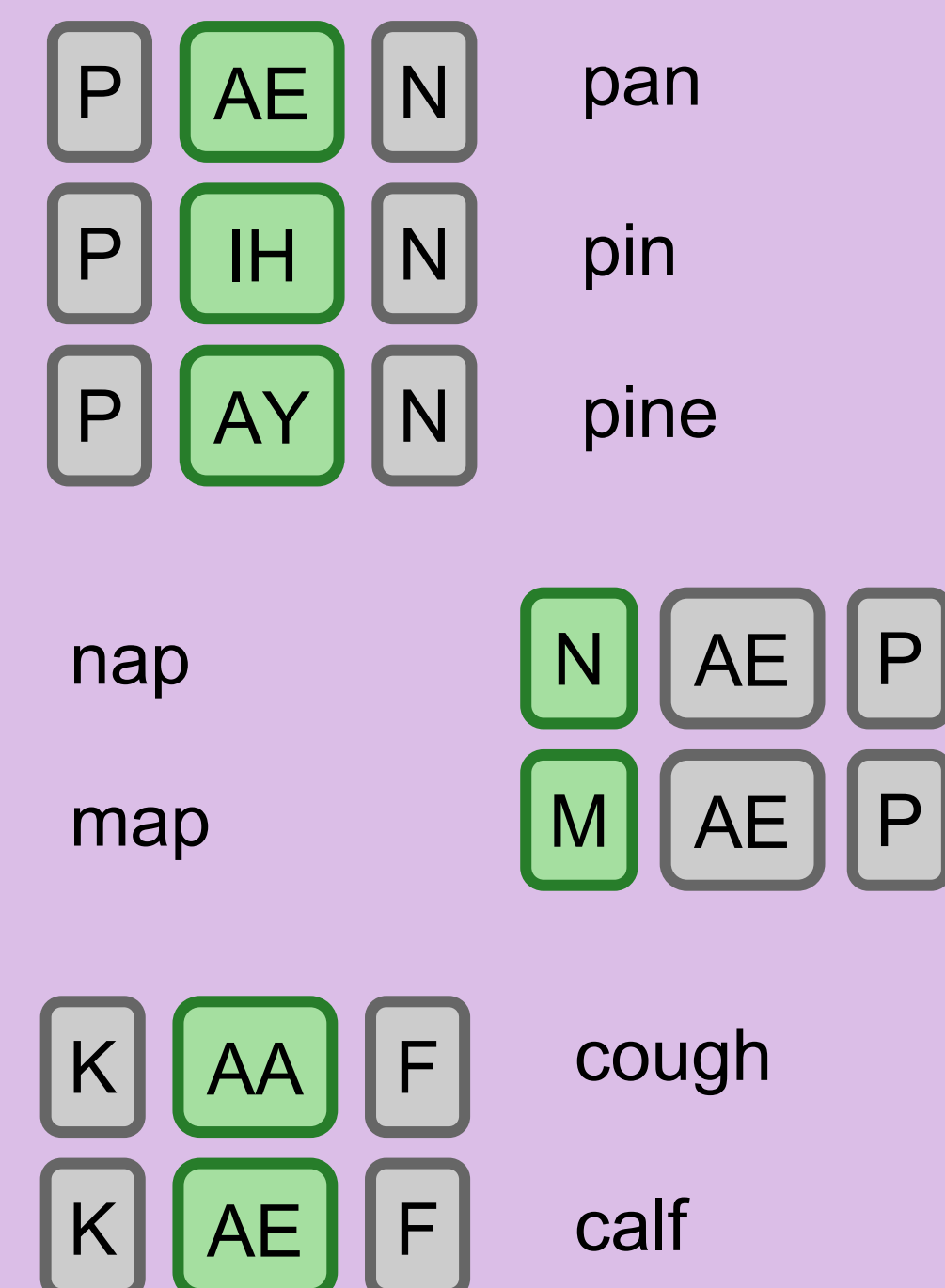
- Tests students' ability to match a word they hear with a word they read, and vice versa

Pick the Misspelling

- Multiple-choice questions where students must select which one of up to four words is misspelled, given each word's audio pronunciation
- Follows several rules to generate misspelled words:

melt → replace one letter → nelt
batch → replace a digaph → batsh
branch → drop one letter → brach
hello → drop double letter → helo
twist → insert vowel → tewist
helmet → swap letters → hemlet

- Tests students' ability to find discrepancies between words they hear and words they read

Spell the Word

- Drag-and-drop puzzle where students choose from a pool of letter tiles to fill in a missing syllable in a word they hear

CONVERSATION → C O N _ _ _ S A T I O N

- Use commonly-confused letters to generate distractor as before

[V][R][W][O][E][I][A]
C O N _ _ _ S A T I O N

- Eliminate any letters that appear in a homophone of the word, but not in the correct syllable, from the letter pool, so that each puzzle has only one correct answer
- Eliminate u from this letter pool:

SOLE → [S][C][A][O][E][L][U] _ _ _ _
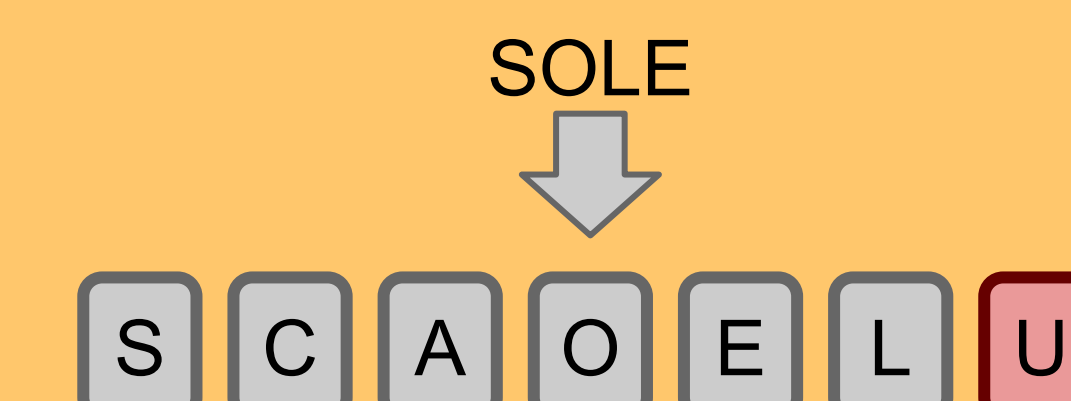
- Tests students' spelling ability on the single-letter level

Results and Conclusions

We conducted a survey to assess the quality of our generated questions, particularly the Pick the Misspelling and Spell the Word exercises.

We assembled 25 hand-crafted and 25 computer-generated questions of each type and asked 16 volunteers to decide if each question was created by a computer or a human, or if they could not tell.

We measure precision and accuracy according to

$$Precision = \frac{\text{\# correctly identified as computer}}{\text{\# correctly identified}}$$

$$Accuracy = \frac{\text{\# correctly identified}}{\text{\# total questions}}$$

and our results are summarized in Tables 1 and 2.

	L1	L2	L3	L4	L5	Total
P	44.65%	53.50%	60.43%	44.69%	57.70%	52.15%
A	43.31%	50.89%	58.54%	38.77%	51.85%	48.67%

Table 1: Pick the Misspelling results.

	L1	L2	L3	L4	L5	Total
P	38.19%	38.19%	47.92%	44.44%	47.22%	43.19%
A	40.74%	40.19%	47.59%	47.64%	50.73%	45.38%

Table 2: Spell the Word results.

On average, participants did even worse than chance in distinguishing between human- and computer-generated questions, allowing us to say with confidence that our CAPITAL Words algorithms generate realistic and convincing questions.

We are currently developing another application called CAPITAL Passages in order to expand our learning system and reach a more advanced group of literacy users. Passages targets users on the single- and multiple-sentence level by automatically generating reading comprehension questions that test students on information found throughout the passage.

References

[1] "Outreach Resources for Services to Adult New and NonReaders." American Library Association, n.d. Web. 13 Nov. 2014.
[2] Smith, Aaron. "U.S. Smartphone Use in 2015." *Pew Research Center Internet Science Tech RSS*. Pew Research Center, 01 Apr. 2015. Web. 31 Jan. 2016.