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Identifying Pedagogical Functions in University Science and Engineering Lectures

Nílson Kunioshi[1], Judy Noguchi[2], Kazuko Tojo[3], and Hiroko Hayashi[4]
[1]Waseda University, [2]Mukogawa Women's University, [3]Osaka Jogakuin University, [4]Osaka University (Japan)
nilson@waseda.jp

Abstract

A corpus of transcriptions of science and engineering lectures was built, and pedagogical functions were identified. Transcriptions of lectures related to basic science courses (Physics, Chemistry, Biology, and Mathematics) were downloaded from MIT OpenCourseware (MIT OCW, http://ocw.mit.edu/index.htm) and those of more specialized engineering lectures (Information Science, Advanced Mathematics, and Robotics) from Stanford Engineering Everywhere (SEE, http://see.stanford.edu/). As of January 2014, 430 lecture transcriptions were compiled as OnCAL (Online Corpus of Academic Lectures, http://www.oncal.sci.waseda.ac.jp). Expressions that teachers use frequently for each pedagogical function were identified to show how the functions are actually realized in classroom spoken language. The OnCAL interface allows users to easily search for words or expressions and see how they are used in lectures. The interface also allows users to discover other functionalities in an intuitive way, for example, restrict searches to one specific field of study or to a set of undergraduate courses. Links to the recordings of the lectures, which are available at MIT OCW and SEE, are provided to allow users to check pronunciation, rhythm, gestures of the teacher, or how the spoken mode is combined with the use of the blackboard. Important pedagogical functions were identified based on the literature and considerations about what would be most insightful for teachers and students. For example, "link to previous content" is appears in lectures when teachers explain new concepts using or citing content that was presented previously. This is one of the ways through which pedagogical link-making is realized. Expressions like "as I mentioned before", or "last time we saw that" are typical of this function, which is important for promoting continuity of the teaching/learning process. Users of OnCAL who select this pedagogical function and press "Search" can see many examples actually uttered by teachers to realize the selected function in the classroom. Because the role of language in science education is known to be important, and clarity, classroom management, cognitive activation, and structuredness have an impact on the quality of instruction, we believe that OnCAL can help improve instruction practice and lecture comprehension. Teachers and students of science and engineering, especially non-native speakers of English, can use OnCAL to gain insights on how to deliver or listen to lectures.

1. Introduction

The use of English as the medium of instruction in higher education is growing rapidly [1]. The ability to attract international students and the pressure for raising international ranking are among the reasons for this trend [2], and English-medium instruction seems to contribute to success in enhancing attractiveness and ranking [2, 3]. In 2009, the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) launched the "Global 30" project to encourage Japanese universities to offer undergraduate and graduate programs taught completely in English to attract more international students [4].

A shift to English-medium instruction in countries where English is not the native language poses challenges to both students and teachers. Students who are non-native speakers of English (NNS) have difficulty listening to and sufficiently understanding lectures delivered in English, and teachers need to deliver effective academic lectures in a second language. Both listening and delivery tasks require an understanding of the academic lecture framework, as well as the ability to fluently

receive/produce the academic content in real time. 'Simple' problems related to vocabulary can be stumbling blocks for students [5]. Issues faced by students learning in a second language have been the subject of much research in different countries. First-year students in Hong Kong needed to have strong motivation, work hard, use effective learning strategies, and receive support to be successful in the adapting to a second language environment [6]. For students learning physics concepts, an investigation of the effects of the medium of instruction on student performance led to the recommendation that teachers encourage students to ask questions during or after class, give out lecture materials in advance, and use more visual illustrations in addition to oral explanations [7, 8]. The challenges faced by teachers and students of mathematics and science in Malaysia around 2003, when English became the medium of instruction, have also been reported [9].

In a science classroom, spoken communication is just one of the modes exploited by teachers [10], but the role of spoken language in science education is still very important [11, 12] and especially in the case of English-medium instruction in a NNS environment, improvement in the quality of instruction cannot be achieved without a careful look at the classroom spoken discourse. We developed OnCAL, the Online Corpus of Academic Lectures (http://www.oncal.sci.waseda.ac.jp/) [13] with the belief that a corpus of university lectures in science and engineering could contribute to improving the quality of instruction by offering linguistic options that NNS teachers may be less aware of, and also foster the lecture comprehension skills of NNS students. In this work, we show how a pedagogical function in lectures is realized by teachers, and how words/expressions typical of that pedagogical function were identified. OnCAL should help NNS instructors prepare lectures in English and NNS students improve their listening comprehension by becoming aware of how these words and expressions are repeatedly used in academic lectures.

2. Methods

2.1 Corpus building

Transcriptions of lectures related to science and engineering were downloaded from MIT Opencourseware (MIT OCW, http://ocw.mit.edu/index.htm) and Stanford Engineering Everywhere (SEE, http://see.stanford.edu/). The Creative Commons License (http://creativecommons.org/licenses/by-nc-sa/3.0/us/deed.en_US) allows the use of the contents as long as these are "shared alike".

Relevant data related to the transcriptions uploaded to OnCAL are shown in Table 1. Some slight editing was done (for example, single quotation marks were changed to double quotation marks) for consistency along different texts and sources.

Detailed data related to each single lecture are available online (http://www.oncal.sci.waseda.ac.jp/lists.aspx). As of January 1, 2014, the total number of lecture transcripts uploaded to OnCAL is 430; the corpus comprises 3.5 million words, which correspond to a total lecture time (obtained from the length of the video recordings) of 395 hours.

2.2 Interface design

We designed the user interface so that functionalities can be "discovered" in an intuitive way, but we also assumed that users can learn the functions from trial and error. Information about how to conduct searches or how to sort the search results is made available online. The search conditions can be changed easily; e.g., a search can be restricted to a particular field, a particular source, or a particular pedagogical function.

Table 1. List of lecture courses uploaded to OnCAL (as of January 1, 2014)

No.	Field	Source	Student year	Lecture time (hh:mm:ss)	No. of words

1	Chemistry	MIT	1st	27:23:08	185,290
2	Physics: Mechanics	MIT	1st	28:44:35	228,582
3	Physics: Electricity/Magnetism	MIT	1st	30:11:40	248,620
4	Biology	MIT	1st	28:37:51	240,627
5	Math: Calculus	MIT	1st	28:20:14	201,194
6	Math: Differential Equations	MIT	1st	25:24:31	189,548
7	Computer Sci. (CS): Programming Methodology	SEE	Undergrad	22:17:30	292,165
8	CS: Programming Abstractions	SEE	Undergrad	21:02:25	278,003
9	CS: Programming Paradigms	SEE	Undergrad	22:27:22	214,539
10	Math: Fourier Transform	SEE	Graduate	25:38:05	222,721
11	Math: Linear Dynamical Systems	SEE	Graduate	24:26:52	238,649
12	Math: Convex Optimization I	SEE	Graduate	24:00:06	233,967
13	Math: Convex Optimization II	SEE	Graduate	21:58:28	209,853
14	Artif. Intelligence (AI): Introduction to Robotics	SEE	Graduate	17:35:35	124,223
15	AI: Natural Language Processing	SEE	Graduate	22:01:12	193,299
16	AI: Machine Learning	SEE	Graduate	25:09:12	188,100
Total				395:18:46	3,489,380

2.3 Pedagogical functions

Pedagogical functions are defined here as devices used by teachers to convey content in a pedagogical way. Teachers realize these functions through spoken language and other modes [10], but here we consider only the spoken mode. The functions were identified based on studies of classroom discourse (for example, [14]) and a consideration of what would be most insightful for NNS teachers and students. Words and expressions used frequently to realize each pedagogical function were registered in the OnCAL system, and some of them are displayed when the user chooses a specific pedagogical function.

3. Results and Discussion

Because “clarity, classroom management, cognitive activation, and structuredness have an impact” on the quality of instruction [15], it is important that teachers be aware of concrete ways to improve instruction. We hope that teachers can obtain insights from OnCAL and its list of pedagogical functions. Table 2 presents a list of the pedagogical functions identified as of January 2014, with their descriptions.

Here, we examine the pedagogical function “LinkToPrevContent”, used by teachers to promote continuity along subsequent sessions during a course (which typically lasts for a semester or a quarter). This pedagogical function is important because in science education concepts are developed over multiple sessions spread out over time [16]. It is an example of pedagogical link-making [17], which is needed to help students connect ideas in their meaning-making process. Content is presented in piecemeal, and students are required to use the parts to build a coherent whole.

Table 3 shows the words/expressions identified as typical for realizing “LinkToPrevContent” and all sentences containing those words/expressions were registered in the OnCAL system. When a user selects “LinkToPrevContent” and presses the Search button without inputting a search string, some of the sentences containing the registered words/expressions are displayed. If the user inputs a string, selects “LinkToPrevContent”, and presses the Search button, the search for the specified string is restricted to sentences containing the words/expressions registered for “LinkToPrevContent”. When the user inputs “mentioned”, selects “LinkToPrevContent” and presses Search, 72 sentences are found. The first hits are:

> so I've already **mentioned** the conditioning also
> As I also **mentioned**, if we look at a Petri

I may have **mentioned** that last time, but
I think I may have **mentioned** this earlier in class

For reference, searching for "mentioned" without restricting the search to a particular pedagogical function leads to 274 hits. Many of these are related to linking to content presented in previous lectures, or earlier in the same lecture. Some examples are:

polymerization that I just **mentioned** can be extended to
interesting molecule because, as I **mentioned**, it can come in
chemical techniques, as I **mentioned** in a previous lecture,

This means that many sentences related to "LinkToPrevContent" are lost when the search is restricted to that pedagogical function. However, the 72 hits for "mentioned" in "LinkToPrevContent" are hopefully sufficient as references for linguistic possibilities of which NNS teachers and students are less aware. We will continue looking for ways to obtain more meaningful hits.

Table 2. List of pedagogical functions identified in science and engineering lectures

Function	Description
ClassManagement	Announcing, framing, summarizing class content
ScientificFacts	Describing relevant discoveries
LinkToPrevContent	Linking ideas for promoting continuity along sessions
Examples|Alternatives	Giving examples or alternatives
UsingVisuals	Math formulas, graphs, pictures in explanations
Cause|Effect	Explaining cause-effect relationship
Conditions	Stating conditions of validity
Analogy	Using analogy to explain a concept
ThoughtExperiment	Using thought experiments to explain new content
Emphasis	Giving emphasis/calling attention to the topic
ElicitReply	Question to initiate interaction, elicit thinking, or check comprehension

Table 3. Example sentences for the words/expressions registered for "LinkToPrevContent"

Words/Expressions	Example sentences
last time	At the end of our discussion **last time** we talked about…
we* before	And that is, as **we said before**, the tertiary structure…
(I | we)* earlier	So, as **I mentioned earlier**, RNA editing involves…
(I | we)* previously	…optimization problem, which **we did previously**,…
remember	…you may **remember** that earlier in the semester…
recall	So you **recall**, and I mentioned, that Mendel studies...

4. Conclusion

Pedagogical functions and their typical words/expressions were identified in OnCAL, the Online Corpus of Academic Lectures. NNS teachers and students can obtain from OnCAL insights into how to better deliver or listen to lectures, respectively, by becoming more aware of the linguistic possibilities through which each pedagogical function may be realized. Not all example sentences related to a pedagogical function could be retrieved, and further work is needed to find ways of displaying more relevant example sentences for each pedagogical function.

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