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Foundations of an Individualized Language-Teaching Expert System

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Introduction

Emerging technologies open possibilities for language teaching and learning that have not been possible in the past. Language learning has traditionally been, and still remains, handicapped by a variety of scarcities greatly influencing the efficiency of the language learning process.

To exploit the new possibilities these emerging technologies enable in the language learning process, we need to re-examine our notions and roles of teachers, classrooms, and materials and leave behind those that provide fewer benefits than are provided by alternatives. To take a step in this direction, I attempt to put aside pre-existing ideas of language learning as we have experienced it and consider an ideal language learning process, free of many of the current constraints. Having established a target paradigm, I will look at how current and emerging technologies can be applied to create a language learning system more suited to this ideal.

In order to keep the discussion at least relatively pragmatic, I confine the discussion to currently available and emerging technologies. For this discussion, emerging technologies will be defined as technologies that have potential to be applied to language education, proof of concept has been established, but have not been applied to language learning to the degree that they have been implemented and evaluated, either through practice or academic study. This rather tight definition should keep the discussion within the realm of what would be possible to achieve within the next few years if aggressively pursued. Which of course means that physical enhancements, neural implants, and uploading lessons to the brain remain outside this definition.

Preconceived assumptions

We have reached the current state-of-the-art of the field of language education in an environment of scarcity of teachers, location, materials, time, and cost. Each of these has had its effect on how the field has become what it is and each also imposes limitations on how, and how efficiently and effectively, language is taught and learned.

As technologies evolve, it is important that we let go of paradigms that continue to keep us within

old, unnecessary constraints and stop us from exploiting what may be better alternatives.

Much of what I describe here could be judged as obvious when it is pointed out, but at risk of appearing simplistic, I want to attempt to expand the paradigms of what is possible and preferred, because although potentially obvious, when making these decisions it is not uncommon to remain within our paradigms based on what has worked in the past under old technological conditions.

Example of the influence of paradigm

Decisions about class size offer a good example of how paradigm can influence perspective. When we think of prefered class size, generally we would judge smaller teacher to student ratios as better than larger. However, still thinking from a classroom, scarce-teaching resource perspective, it is also common to assume that having, say, under ten students would be preferable to having a 1:1 ratio. In the paradigm of the classroom or traditional tutoring environment, a 1:1 ratio would limit the interactions that would take place. It would remove the possibility of the learner occasionally moving into the role of observer of interactions, force them to be the focus 100% of the time, and limit the variety of interactional partners. It would be easy then to conclude that an ideal teacher/student ratio would include more than one student. However, stepping outside of traditional paradigms and assumptions of teacher scarcity, would it not be better to have additional instructors that the student could observe interacting when the focus is off the student? This is not practical under traditional paradigms, but emerging technologies--where the teachers are computer based--open up this possibility.

The following section of is meant as a paradigm shifting exercise to precede the presentation of a non-traditional approach to language learning/teaching and is in no way an attempt at a thorough deconstruction of the field. I can say that I have a heavy bias toward the belief that technologies, material or conceptual, lead methodological approaches, which tend to lag behind.

Toward an ideal

So, what form would the ideal language teaching and learning process take? My first step in attempting to conceive and ideal process is, as a mental exercise, to remove each of the scarcities mentioned above. I am not attempting to argue at this point that each item here is achievable, only suggest that the full or partial removal of each of these scarcities would have a positive effect on the teaching and learning process, potentially shifting the target ideal out of the classroom.

Number of teachers

Removing from the equation the constraints of limited teaching resources, we can imagine allocating a private instructor (or even multiple private instructors) to each learner, as in the above scenario, that alone could be argued to create a great improvement in the progress of the student. There are definite benefits to having other students in a class rather than always having a one-on-one session with the teacher, but wouldn't it be even better if rather than other students (who make

errors and have limited knowledge of the target language) additional instructors were included in the learning experience?

Location

Removal of the constraint of location, the learning experience could be with the learner wherever they are, any available time, in any appropriate location the lesson could take place.

Materials

I imagine non-scarce materials to be free and instantly available lessons and activities covering the continuum of difficulty levels. A comprehensive, crowd-sourced, Wikipedia-style lesson repository project is not beyond the scope of what could be accomplished.

Time

Time concerns both the teacher and the learner. Short of physiological or chemical alteration of learners, the time taken to learn appears to be fixed. There do not appear to be any improvements to this on the horizon. I'll have to consider the time a student spends engaged in learning as an unchanging variable for this discussion. However, I will consider the potential effects of non-scarce teacher time (cf. the number of teachers). I believe that we can consider that unlimited resources of teacher time would have a positive effect on learning.

Knowledge of the student

Another scarcity that is easily taken for granted is the teacher's knowledge of individual student's knowledge and ability. We have course prerequisites, quizzes and tests, and our interaction with students that allow us to form a general idea of each student's level, but there is much we don't know. Removal of this scarcity would mean that the teacher would have a thorough knowledge of every skill and item of knowledge the learner possesses and also, therefore, everything that they do not know.

So, an ideal teaching and learning process, would have all of these qualities. The teacher would be available anywhere and any time the student wished for a lesson, it would know exactly what the student needed and draw lessons and exercises from an exhaustive pool of materials to provide individualized instruction of exactly what the learner needs at the time. Assuming that learner needs include conversational interaction, it could serve as a target language speaking companion, or even multiple companions.

I wish to argue that each of these scarcities has the potential of being reduced or removed by emergent technologies and could result in a much more efficient and effective language teaching and learning process. And with this as a target, I will describe in the sections below, the form that a

learning system of this kind could take.

An Individualized Language-Teaching Expert System

An expert system is an artificial intelligence that emulates the decision making and reasoning of a human expert (Jackson, 1998). I'll describe in the following sections the form that a language-expert system could take. The model is made up of process and data nodes. As seen in Figure 1, the processes are represented by the white boxes and the data is represented by the grey boxes. Except for the lesson bank, all data nodes are created by a process node and then used by the next process node in a cycle. There are three main process nodes in the cycle consisting of *Needs Assessment, Lesson Selection, and Interaction with Learner*. There are two inputs into the main cycle; the *Comprehensive Lesson Bank*, and the *Environmental Profile* created by the *Environmental Scan*. The former being a repository to be accessed for *Lesson Selection*, and the latter to inform the *Needs Assessment*.

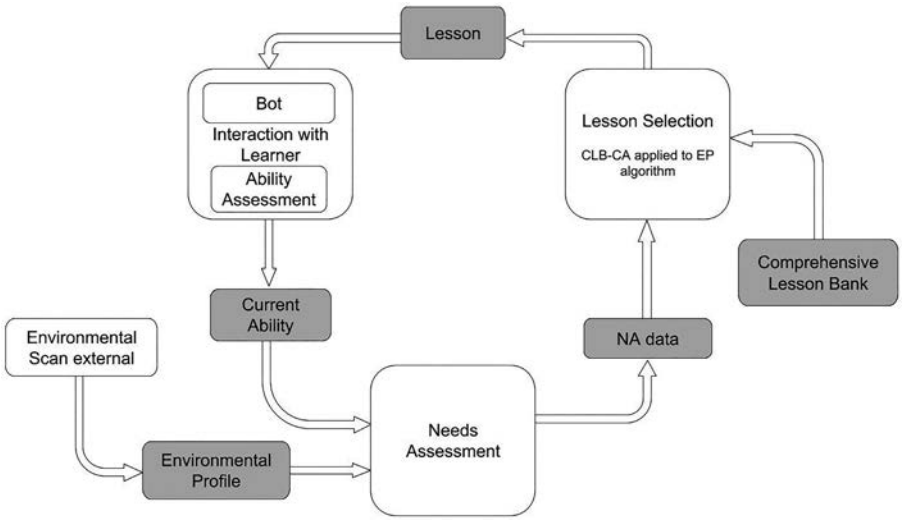

Figure 1. Language-Teaching Expert System Workflow

Core Processes

Effective curriculums include feedback that allows the process to continually adapt to the current needs of learners (J. D. Brown, 1995). The model in this study is built upon three core processes that result in a feedback loop of continual adaptation influenced primarily by a needs assessment updated with each cycle. Being cyclical, there is no clear starting point from which to describe the entire process, as each process is influenced by that which preceded it. I begin with the *Needs Assessment* which will make reference to the preceding processes which will in turn be elaborated on further as we progress through the cycle.

Needs Assessment.

The *Needs Assessment* receives the data from the *Current Ability* data node and *Environmental Profile* data node. The *Needs Assessment* creates the *Needs Assessment Data* that will be then used for *Lesson Selection*. The *Current Ability Data* the *Needs Assessment* process establishes what knowledge and skill the learner has acquired and what they have not. The *Environmental Profile* node adds to this from the learners *Environmental Scan* what likely has priority to the individual learner.

Lesson Selection.

Lesson Selection takes in the *Needs Assessment* data, which could be characterized as everything the *Needs Assessment* established that the learner cannot do, with extra weighting given to skills and knowledge that may be of immediate importance or interest to the learner. The *Lesson Selection* process then weights this data, taking into account difficulty levels, and retrieves the appropriate lessons from the *Comprehensive Lesson Bank*. This process would also incorporate a spaced retrieval system to select previously learned content that are ready for review. Having done this, the *Lesson Selection* process then produces the output data referred to in Figure 1 as the Lesson.

Interaction with Learner.

The *Interaction with Learner* process receives the *Lesson* that was chosen by the *Lesson Selection* and presents it to the learner. This could take a variety of forms and, of course, some could resemble traditional *Present, Practice, Produce* interactions, however lessons and practice could be incorporated into casual conversation, as asides, as are done with human companions who speak a learner's target language. (I imagine that there is an ideal ratio of study to situational language use, but I have not found reference to it yet in the literature.) Let's assume for discussion that it is 1:20. Aside from delivering the lesson, the *Interaction with Learner* process would use this stage to pad the interaction with conversation which is strategically interspersed with language items in need of review, drawing on a spaced retrieval algorithm.

Aside from delivering *Lessons* and review, the results of interactions with the learner would also be continually assessing learning outcomes, referred to in Figure 1 as *Ability Assessment*, which would then create the data output referred to as *Current Ability*.

Environmental Scan

External to the main cycle is the *Environmental Scan*. The *Environmental Scan* attempts to create a thorough profile of the learners linguistic environment, potentially including daily conversation, the learners audible and visual receptive physical environment, receptive media environment, and receptive and productive digital environments. This is essentially all language (and possibly the vocabulary of the objects in the learner's physical surroundings) perceptible to the learner in their

daily life.

It is not difficult to imagine how this would be done with the digital environment, with Google and various government agencies having pioneered methods through collection of marketing data and domestic intelligence collection (such as the PRISM electronic data mining program exposed by Edward Snowden). However, Microsoft took this further with it's Lifelogging project, in which wearable audio and video recording devices were attached to participants in an attempt to collect data from the participant's physical daily environment (O'Hara, et al., 2008). In addition, Bell (2007), in his similar MyLifeBits project, "captured a lifetime's worth of articles, books, cards, CDs, letters, memos, papers, photos, pictures, presentations, home movies, videotaped lectures, and voice recordings and stored them digitally", extending it to include phone calls, instant messaging transcripts, television, and radio.

While there is potential for misuse of data of this breadth, a potential benefit also exists and collection of data of this kind paired with *Learner Ability* data collected from the *Interaction with Learner* process would result in an extremely low scarcity of knowledge of the learner and provide rich data from which to create a very robust *Needs Assessment* of each individual learner.

Comprehensive Lesson Bank

There are a great number of lesson repositories, Moodle.org probably being the most widely known. To be most effectively exploited, a lesson repository would first need to be comprehensive. With probably millions of English lessons being created daily, the redundancy in the system is enormous, with the very best lessons being lost to the majority of teachers. Although lesson repository projects have made attempts to make quality premade lessons widely available, they remain scattered and far from comprehensive. I imagine a Wikipedia-style project that is continuously expanded, improved and curated. I place this outside of the language learning expert-system model because the process involves other actors, whereas all other process in the system are carried out internally by the expert system, therefore, the *Comprehensive Lesson Bank* enters the model as data.

So what about textbooks as lessons? I do not consider textbooks here, because textbooks are a symptom of the classroom paradigm and deliver lessons as a package, intended to meet the needs of a number of individuals in the classroom, making them specialized to none of the learners. This meets the needs of the traditional classroom paradigm, but is not compatible with the system I describe.

The Bot

The final element of the model to be described is the bot, which will serve as the interface between the system and the learner. This technology is emerging in the form of a chatbot. A chatbot is a computer interface that allows humans and computers to interact using natural human language. This is one of the more exciting emerging technologies. Computers that linguistically interact with humans have been speculated on and have appeared in fiction for decades. Atwell (1999) proposed the serious potential of a computer-based, conversational, language-teaching system near the turn of

the millenium. And more recently Ask et al. (2016) describes the emergence of chatbot technology into the mainstream:

> Facebook Messenger had zero bots in February 2016 and over 18,000 by July 2016. it took Apple more than seven months to reach that mark with apps. Kik interactive has more than 20,000 chatbots. In the first seven months that Kik interactive allowed Promoted Chats, its 200 million registered users exchanged 350 million messages with bots.

Even more recently, many businesses are adopting chatbots as a way to interact with customers (Heo & Lee, 2018). Through voice recognition and speech synthesis, voice based chats are making it possible to have a conversation with your computer as you walk down the street. Deep learning, engaging neural networks, is being applied to these technologies to improve them further (Xie, et al., 2018). Within prescribed domains, chatbots can pass off as human. Ashok Goel, as described by Molnár & Szűts (2018), created a chatbot system to answer the 10,000 inquiries that were received from students regarding his class. The chatbot replied to students for an entire year without being identified as not being a human.

These technologies could be developed to specialize in interactive conversational language, teaching interactive lessons, administering tests and assessments, small talk, and conversation.

As an element of the *Interaction with Learner* process, the learner's interaction with the chatbot contributes to the *Current Ability* data.

User experience

The main features of the user experience would be the hardware and the chatbot. The chatbot could take the role of a companion, interacting with the learner throughout the day, engaging them in conversation, exploiting "teachable moments" to spontaneously insert a lesson into the dialog, commenting on errors it observed in the learner's production, and providing alternatives, or normal error correction. There could also be time set aside for more explicit lessons, especially when visuals would better serve the lesson. For sit-down lessons, the chatbot could serve as a reference source, and provide feedback. This all could, regardless of location, serve as an immersive language learning experience.

The hardware, depending on the level of comprehensiveness chosen by the learner, could include the collection of all receptive and productive digital sources, as well as audio and video of the physical environment. This would require cameras and audio recording devices. Recently these can be physically, at least, rather non-intrusive. It would also be possible to include augmented reality, a digital layer added onto the perceived environment. This could add labels or comments to objects in the environment or potentially translate text in the environment into the target language. (For a basic, and still rather glitchy, sample of this see the camera function of Google's Translate app.)

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