Teaching ESL and Instruction Design with Computational Thinking and Robot-Assisted Language Learning

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Abstract—Living in the 21st century, it seems impossible for everything to develop without technology, critical thinking, and computational thinking. This paper is to address the application of computational thinking on English as Second Language (ESL) teaching and robot-assisted language learning. After illustrating that computational thinking is a process to solve problems, while computational linguistics is a field concerned with the statistical or rule-based modeling of natural language, this paper gives a brief introduction of the Language Acquisition Device theory and how ESL teachers design the instructions and teach English by following the computational thinking process. Robots, however, can also be used to interact with English language learners and to help them with their speaking skills in the 21st-century classroom.

Keywords-Computational Thinking; Computational linguistics; ESL instruction; Robot-assisted language learning.

I. INTRODUCTION

Computational thinking (CT) is a problem solving process that includes a number of characteristics, such as logically ordering, analyzing data and creating solutions using a series of ordered steps; and dispositions, such as the ability to confidently deal with complexity and open-ended problems. CT is essential to the development of computer applications, but it can also be used to support problem solving across all disciplines, including math, science, and the second language learning.

Currently, CT is broadly defined as a set of cognitive skills and problem solving processes that include (but are not limited to) the following characteristics [8][9]:

- Using abstractions and pattern recognition to represent the problem in new and different ways.
- Logically organizing and analyzing data.
- Breaking the problem down into smaller parts.
- Approaching the problem using programmatic thinking techniques such as iteration, symbolic representation, and logical operations.
- Reformulating the problem into a series of ordered steps (algorithmic thinking).
- Identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources.
- Generalizing this problem-solving process to a wide variety of problems.

Computational linguistics (CL) is an interdisciplinary field concerned with the statistical or rule-based modeling of natural language from a computational perspective, as well as the study of appropriate computational approaches to linguistic questions. The theoretical goals of CL include the formulation of grammatical and semantic frameworks for characterizing languages in ways enabling computationally tractable implementations of syntactic and semantic analysis; the discovery of processing techniques and learning principles that exploit both the structural and statistical properties of language; and the development of cognitively and neuroscientifically plausible computational models of how language processing and learning might occur in the brain [7]. Today, CL often works as a member of interdisciplinary teams, which can include regular linguists, experts in the target language, and computer scientists.

In this paper, we are going to address the application of computational thinking on English as Second Language (ESL) teaching and robot-assisted language learning. In Section II, the Language Acquisition Device theory shows how the human mind processes language acquisition of children's innate predisposition. Additionally, Section III gives a brief introduction of how ESL teachers design the instructions and teach English by following the computational thinking process. Robots are discussed in Section IV that they can also be useful in interacting with English language learners and to help them with their speaking skills in the 21st-century classroom.

II. UNIVERSAL GRAMMAR (UG) IN LINGUISTICS

The theory of universal grammar proposes that if human beings are brought up under normal conditions, then they will always develop language with certain properties. For instance, our brains can distinguish nouns from verbs, or distinguish the function words from the content words. The Language Acquisition Device (LAD) is a hypothetical module of the human mind posited to account for children's innate predisposition for language acquisition [1], and is a concept of an instinctive mental capacity that enables children to acquire and produce language, same as the process of how computers classify different documents. For example, we put verbs in the "verb" folder, or distinguish the Microsoft Word document by ending of ".doc". The theory proposes that there is an innate, genetically determined language faculty that knows these rules, making it easier and

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faster for children to learn to speak than it otherwise would be.

Chomsky [1] states that the development of language in the individual must involve three factors: (1) genetic endowment, which sets limits on the attainable languages, thereby making language acquisition possible; (2) external data, converted to the experience that selects one or another language within a narrow range; (3) principles not specific to the Faculty of Language.

As an interesting side note of historical importance, Chomsky made a number of important advances in the field of computer programming languages. He is credited with the development of the Chomsky hierarchy, a rigorous mathematical model of grammar [5]. Both of the mathematical model of grammar and universal grammar theories are vital and a great advance to the field of computer science and programming language theory.

III. COMPUTATIONAL THINKING IS APPLIED TO ENGLISH LANGUAGE TEACHING/LEARNING

Teachers in Science, Technology, Engineering, and Mathematics (STEM) focused classrooms that include computational thinking, allow students to practice problem-solving skills, such as trial and error [10]. Basically, computational thinking is an iterative process based on three stages:

1. Problem formulation (abstraction);
2. Solution expression (automation);
3. Solution execution and evaluation (analyses).

However, why can we not apply the computational thinking process to the English as a Second Language (ESL) teaching in the classrooms? Therefore, this will be how ESL teachers structure the language teaching or design the instructions by following the computational thinking process [3]:

- Exploration

During the exploration phase, teachers can let ESL students watch some movie clips in English, whose contents should be related to what grammar or vocabularies they are current learning, such as the simple past tense, or vocabularies of different colors or animals. After watching the materials, students will be given a series of structured activities to engage in the production writing and speaking skills.

- Analysis and breakdown

This phase focuses on the analysis of the student's comprehension of the materials and the elements they have found, such as new vocabularies, grammar features, etc. Particular attention should be drawn on certain elements. For example, the present progressive tense has been used whole time in the story that they watch. Then, the students will be encouraged to use the present progressive tense make sentence to talk about what things are happening in their real life. Also, as part of this analysis, students will be asked to write down the sentences they thought could best express the meaning of the story. Each student will choose the most important sentences for the whole class brainstormed, and then they will come up the main line of the story they read or the video they watched.

- Identification of language patterns and theme

Identification of language patterns and theme is the process of the study of the grammar, which focuses on how language elements are ralted to each other and the rules are established. A parse tree, as an example shown in Figure 1, models the grammar of a language and expresses the grammar in a way that clarifies the meaning of the elements in the language [5]. The word "thinking" is classified as a noun as a lower level of the parse tree. Meanwhile, the three-word "the educated student" is classified as a noun phrase at the higher level of the parse tree.

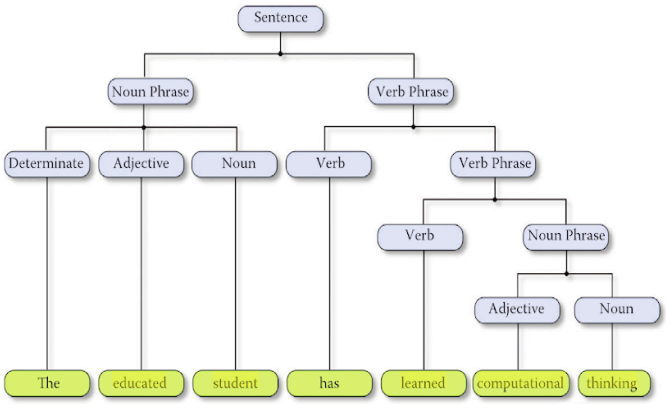

Figure 1. The structure of an English sentence is shown in this parse tree.

- Abstraction

If the previous stage is to let students generate a complete sentence by following the structure of the parse tree, then this step is to ask them to organize a short story following the five "wh-" question and one "how" question shown as TABLE 1.

TABLE 1. THE FIVE "WH-" QUESTIONS AND ONE "HOW" QUESTION.

WHAT	Describe the story you want to present.
WHO	What are the characters in the story?
WHEN	When does this story happen?
WHERE	Where does this story take place?
WHY	Why you want to write a story like this?
HOW	What does each character interact?

- Implementation: coding with "Scratch"

This is the phase in which students use Scracth.mit.edu to code the movements of the cats, make the scenery based on their own stories. With Scratch, students can program their own interactive stories, games, and animations. Also, they can share their creations with others in the online community. Scratch helps students, including English language leaners learn to think creatively, reason systematically, and work collaboratively, which are the essential skills for life in the 21st century. At this stage each student can works in groups in order to get all together to discuss progress, they help each other with not only the technology problems, but also the language problems. The meetings among group members

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were very important because they allowed to involve all class members and everyone could contribute to the show with his/her point of view. On one hand, it improves students speaking proficiency; on the other hand, it encourages student's teamwork spirit.

- Assessment and improvement

In addition to the checks and adjustments made during the learning process, instead of using tests or quizzes, the students are encouraged to use blogs to share stories or their writing assignments with others online where has more of an authentic writing experience. Since they can get feedbacks from a wider audience typically has access to read posted entries, students will get less anxiety and more motivations to do that, which means students tend to put more effort on it. Also, I believed that language is a communication tool, so students are encouraged to talk about what they have learned and what they did in the classroom in English with their parents and some digital device (e.g., robots, which we will discuss in the next section), in order to build an English-speaking environment outside of the classroom.

IV. ROBOT-ASSISTED LANGUAGE LEARNING

It is effective when second language learners directly interact with a native speaker in a class, and researcher believed that autonomous robots embedded voice recognition technology could perform the role of native speakers to interact with learners [2]. Also, research study has confirmed that this type of interaction between robots and humans not only improves teaching effectiveness but also learning motivation, because students are less anxious and more cheerful [4].

Given the fact that computers cannot conduct open ended dialogues and cannot give feedback to open ended questions [6], these problems can demonstrate that while technology could have much to offer for the learners for its high efficiency in delivering materials and interations. The robot teachers, which enhance English laguage learners' learning process, could fix the difficulties of addressing the complex learner needs and inability to answer open-ended question in real time.

Despite the great benefits of using robots in second/foreign language learning, the current application may be limited because of the two major reasons: autonomous robots have complex artificial intelligence and are so expensive that normally schools cannot afford them. Therefore, an alternative to solving the above problems is to buy robots with simple autonomous functions (e.g., Amazon's Echo, Jibo, Google Home, etc.). These robots are mostly developed in a small size and at a lower cost. Meanwhile, they could be simply controlled by instructors to perform pedagogical missions and teaching materials in the classroom activities for facilitating learner's engagement and oral interaction.

V. CONCLUSION AND FUTURE WORK

With the number of courses steadily increasing to meet students' needs and demands, ESL students are getting more frequently encouraged or required to take English language courses to complete their study in English-speaking countries, or even non-English-speaking countries. Although the development of technology has made language-learning opportunities increasingly more accessible to a growing number of people, there is not too much research about learning English with computational thinking or robots. This paper is aim to call the attention of English language teacher to the use of the computational thinking and technology tools like robots. Future research needs to focus on the pedagogy and instruction design of using the computational thinking process and technology tool (e.g. robots) in the 21st-century ESL classroom.

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