Robotic Chinese Language Tutor: Personalising Progress Assessment and Feedback or Taking over Your Job?

Structured Abstract:

- **Purpose**: The shortage of Chinese language teachers have been identified as a pressing issues globally. The paper responds to the needs by investigating and designing the learning innovation with autonomous programmable robot, NAO.
- **Design/methodology/approach**: By thoughtfully embedding NAO robot into teaching basic Chinese language, this research demonstrates an inquiry qualitative case study of AI design principles and learning engagement with Rule-based reasoning and progress test design.
- **Findings**: This state-of-the arts robot use its emotion recognition and body language automated (LED eye with various colours) to demonstrate the Chinese words, to increase learners' understanding and enhance their memory of the words learned. The responses conclude that the novel learning experience is more fun and interesting, thus the engagement from the axis of novelty, interactivity, motivation and interest is enhanced.
- **Research limitations/implications**: It is recognised that the number of research participants was small but the qualitative finding demonstrate key issues and recommendation that may inspire future empirical research.
- **Practical implications**: Today, robotics is a rapidly growing field and has received significant attention in education. Humanoid robots are now increasingly used in fields such as education, hospitality, entertainment and healthcare. Educational robots are anticipated to serve as teaching assistants.
- **Originality/value**: The learning engagement paradigm has shifted from manual engagement to personal response systems or mixed-reality on mobile platforms, and now with the humanoid robot, The recommendation of four principles and future work and for designing humanoid robot as a language tutor are discussed. The educational robot model can be changed to a newer robot such as Canbot U05E.

Keywords: Educational robotics, NAO robot, Chinese language education innovation, Assessment and feedback

1. Introduction and Background

Today, artificial intelligence (AI) and robotics are rapidly growing fields that have received significant attention in the UK parliaments and international scenes (AI Select Committee, 2017). The recent two years of educational AI lies on mobile platform, game-based learning or online analytics system on a computer machine, VR/AR or mixed reality (IJAIED, 2020). For examples, both the research of smartphone Python tutor (Fabic, Mitrovic and Neshatian, 2019) and Teachable Agent-based game with eye-tracking capabilities (Gulz, Londos, and Haake, 2020) showed that the AI are effective in enhancing learning and teaching. Limited literatures, nevertheless, are focused in educational humanoid robotics. AI and humanoid robots is not a speculative science fiction but practical technologies increasingly used in innovative research and interdisciplinary applications in education, hospitality and healthcare sectors (IBM, 2016; EUREKA Robotics, 2020). However, how novel and constraint the

educational robots are are yet to be explored. Some robots act as teaching assistants for elementary school students in the international scene (Cuadrado, Riesco and López, 2016; Lim, 2017). During the likely period of disruption versus innovation, however, the unnecessarily public anxiety and levels of public literacy for introducing robot teaching assistant needs to be informed and balanced (British Academy, 2017). The UK Parliament Education Committee (2018) launched inquiry into the Fourth Industrial revolution, which is characterised by the emergence of a range of new technologies including AI and robotics.

On the other hand, Chinese is one of the most difficult languages in the world and has increasingly attracted both parents' and students' interest to learn as a second language (Shao, 2015). The shortage of Chinese language teachers have been identified as a pressing issues globally (Tinsley and Board, 2014; Haur, 2015). Is there any synergy between the Chinese language teaching and an educational humanoid robot with AI capabilities? There is also a gap between student expectations and learning and teaching experience. Students complain that the classroom today is boring and not engaging. It is found that 87% of 2500 teachers in the US felt the digital gadgets have created an "easily distracted generation with short attention spans" (Jeffries, 2013). The question to ponder, at this point, is that how the innovative intervention of a robot tutor can engage (or disrupt) students in learning Chinese language? It is asserted that the value of a robot with AI capabilities reflects the values of those who program it and use it; and there are debates for ethical, pedagogical and public readiness in introducing robotic teaching assistants (Chew, 2017). Hence, the aim of the research is to investigate the students' engagement (emotional and cognitive) by thoughtfully design and pilot a humanoid robot in teaching basic Chinese language, with ethical-pedagogical reflections.

2. Methods and Design Thinking

Qualitative case study research has an important stance in educational evaluation (Yin, 2014) and thus is chosen as a research method for the investigation. This is a systematic inquiry case study into a phenomenon of technology choice of educational robot with AI design as follows: (1) Designing and identifying a case study: the choice of technology and targeted sample; (2) Establishing the AI logic and design for the educational robot programme for Chinese language teaching; (3) Reasoning Implementations for intelligent assessment and feedback; (4) Collecting case study evidence: robot-collected data and qualitative interviews for a small size pilot; and (5) Analysing and constructing case with the triangulated data and the reflections of engagement theory: novelty, interactivity, motivation, interest and challenges (O'Brien and Toms, 2008).

A systematic review of the current humanoid robots is conducted based on the searched keywords of "robot" and "education" or "learning and teaching". An advanced example in the literatures is ASIMO, which stands for "Advanced Step in Innovative Mobility". It was designed with the aspiration of helping people in needs as it has the good size for helping around the house or classroom (Asimo, 2018). Nevertheless, ASIMO is not available for sale

in the market. Another popular humanoid robot can be purchased is the NAO robot by Softbank Robotics (2020). NAO has a powerful and fully programmable platform with various sensors and language capabilities. Thus, it has been widely used in more than 70 countries for research and education purposes, from primary schools through to universities. The popular Lego Mindstorms and Rasperrypie are two of the cheapest robot but with limited capabilities compared to NAO.

Based on the comparative review of most available humanoid robots, it is found that NAO robot is the recommended choice to use in education enhancement: (1) **Language capability:** It can speak more than 20 languages; (2) **Mobility:** It is small and light, easy to carry everywhere by lecturers or students; (3) **Cost-effective:** It is affordable, available and a lot cheaper compare to another expensive robot such as Pepper, ASIMO and iCub; (4) **Sensors capability:** It has the general abilities such as speech recognition, tactile sensors, computer vision, control and movements needed to interact with the students and lecturers in a fun and humanoid way; (5) **Programmable with logic design:** It has a powerful and fully programmable platform; (6) **Attractive humanoid outlook:** It may create "wow effect" and motivate students with learning engagement (SoftBank Robotics, 2020).

An educational program for learning Chinese with NAO is developed and pilot tested with 6 university students. The qualitative purposive sampling method is used: some of them understand Chinese, some do not understand; students are from two disciplines (Computer Science and Business Studies), indicating technological competence and non-technological competence. Each student would learn Chinese with NAO. Students' responses will be recorded by NAO. The researchers' observation and students' engagement with the Chinese learning sessions were observed and triangulated analysed. After the pilot, feedback forms were distributed to the students to collect their fresh experience for interview. These data were triangulated for the findings. The research adapted O'Brien's and Toms' engagement theory (O'Brien and Toms, 2008) for qualitative data collected by the user experiences with innovative technology that is characterised by the axis of novelty, interactivity, motivation, interest and challenges.

3. Establishing the AI logic and Designing the Reasoning

3.1 Overall Reasoning Design

The development programming language is Python with Choregraphe and a classic AI techniques, Rule-based Reasoning is used for implementation. It contains two basic components: knowledge base and inference engine. Knowledge base is a collection of rules embodying the knowledge, i.e. in this case is basic Chinese language lessons to learn colour, emotion and poetry. Inference engine carries out the reasoning process by scanning the patterns in the rules that match the fact patterns to reach a conclusion (Carini, Kuh and Klein, 2006), i.e. in this case is the pronunciation and learning score of the Q&A sessions. In this research, basic rule-based reasoning with forward-reasoning is applied in many ways. One of the examples is speech recognition. NAO robot has to recognise students' voice in order to react to their questions. Rule-based reasoning is used in a way that when NAO receives some responses through voices, it will interpret the voice and finds the keywords

which match against the data. Then, NAO will answer the audience based on what it received that is pre-programmed using the selection (IF-THEN-ELSE) reasoning:
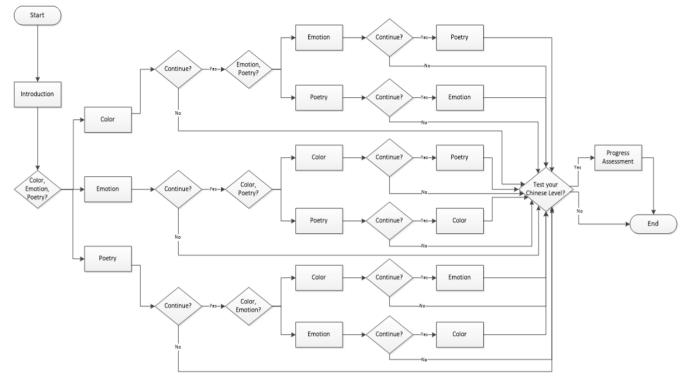

Fig. 1. Overview of the Design and Interactions of Basic Chinese Language Learning

NAO starts by introducing itself as a Chinese teacher. Then, it will ask the students what they would like to learn. There are three options of the designed lessons based on the introductory Chinese language lessons: Level 1 - Colour, Level 2- Emotion and Level 3- Poetry (see Figure 2, 5 and 6). These levels are based on the difficulties of the language lesson. Students can choose to learn three of the lessons, or choose to take either only one or two of the lessons. Before ending the class, NAO will ask the students whether they want to take a short quiz to test their Chinese level. If the students say no, the class will end. If yes, it will proceed to the test session. When the test is finished, NAO ends the class.

3.2 Lesson of Learning Colour in Chinese
   In the colour learning lesson, NAO will teach 4 different types of colours: Red, Blue, Yellow and Green. For each colour, NAO uses his LEDs to present the colour such that his eyes will change colours according to the words. NAO will first say the Chinese word, and the student has to repeat the word. Each word will be taught / repeated twice. During the lesson, student is allowed to skip the word by saying the Chinese word "跳" (skip) or end the lesson by saying the word "停" (stop). Appendix 1 attached the Electronic Supplementary Material, a video demonstration for NAO-student Colour Lesson. NAO's speech recognition function is used to test whether the Chinese word said by the student is correct. An accuracy level will be assigned to the word that NAO heard to indicate the accuracy of the pronounced word. If the value is above or equal to 55, it is excellent. If the value is between 45 and 54, it is good.

If the value is less than 45, it is considered inaccurate and the student will be asked to repeat the word again. Then, the value for each word will be stored in the Record Score python script. Before ending the lesson, NAO is programmed to automatically calculate the total score and send it to the student and educator.
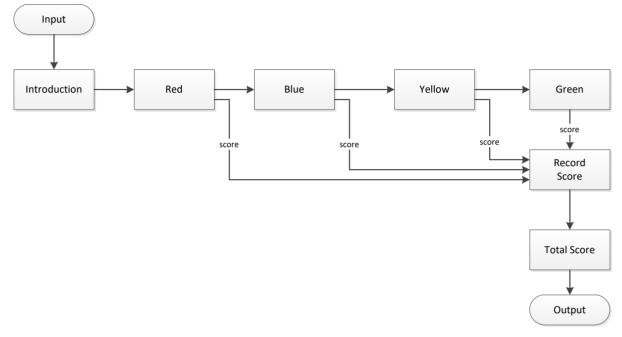
Fig. 2. Flow for Learning Colour

3.3 Lesson of Learning Emotion and Poetry in Chinese

In emotion lesson, NAO will teach 4 different types of emotions: Happy, Sad, Angry and Laugh as shown in the Figure 3 For each emotion, NAO will first say the English word, and then show the emotion. After that, it will teach student the Chinese word that represents the emotion. Appendix 2 attached the Electronic Supplementary Material, a video demonstration for NAO-student Emotion Lesson.
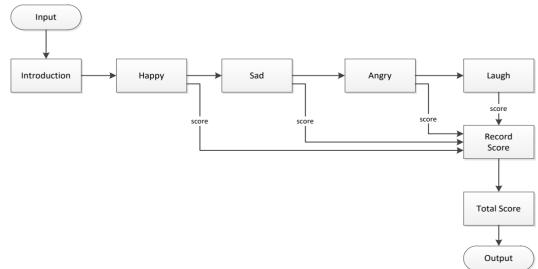
Fig. 3. Flow for Learning Emotion

In poetry lesson, NAO will teach a Chinese poetry which is called, 夜静思 (A Quiet Night Thought) a famous poem written by the Tang Dynasty poet, Li Bai. The poetry is split into four verses to be learnt by the student. The accuracy threshold in this lesson is same as emotion lesson.

3.5 Intelligent Progress Assessment

The rationale of the 'intelligent progress assessment' is for NAO to determine the next level of test or lesson for the students based on the student's previous learning performance. In the intelligent progress test, three sets of questions (Level 1, 2 & 3) have been prepared and the student will have to go through two of them. Each set of questions consists of five words to be tested. The distribution of the second test will be based on the student's first attempt's results.
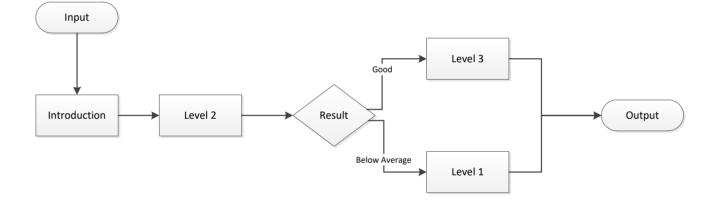

Fig. 4. Flow for Progress Assessment

The level of challenge (Ic) for each question has been categorized, such that the words in color are defined as "easy", emotion are "moderate" and poetry are "challenging". The performance level (plevel) for the test is scale from level 1 to level 3 and the desired performance level is in level 2. The plevel associated with the Ic is designed in the below table:

Performance Level	Easy	Moderate	Challenge	Total
1	3	2	0	5
2	2	2	1	5
3	1	2	2	5

Table 1. Summary of the Association for plevel and Ic

Table 1 shows that the higher the plevel, the more challenging words will be selected. Likewise, the higher the plevel, the fewer the easier words will be selected. Each student's default plevel is assigned to Level 2 upon their registration for the progress test, which

contained 2 easy questions, 2 moderate questions and 1 challenge question. The level of difficulty and performance levels can be extended. There is a smaller set of performance level (pl) which determined the individual test. 70% score is defined as a pl. When the student has completed the first test, the level of challenge will be decreased in the second test if the student's result is below the desired performance level. Likewise, the level of challenge will be increased if the student's result is above the desired performance level (Chew & Jones, 2006).

4. Finding and Discussion

4.1 Novelty
After the pilot walkthrough with targeted research participants, the first response is that all six students were energised to see NAO and engage with the learning process due to the novel and engaging experience:

> *"Creativity and innovation can change the way students interact with learning content and NAO."*
> *"I can learn a lot of Chinese words within half an hour."*

Students who did not know Chinese are engaged with the new learning experience by the refreshing setting of humanoid robot educator for learning and teaching. Most students love the human-robot interactions and expressed that the innovation is more motivating in contrast to self-studying and traditional teacher-students interaction due to the following reasons:

> *"Nao Robot is a new technology and I did not see at elsewhere as a tutor."*
> *"Very unique experiences!"*
> *"Oh my God…the dancing and walking robot attract my full concentration…"*
> *"This is a special learning session – a human teacher plus a robotic tutor, very well blended."*

However, the researchers would assert that once the excitement of the new gadget is passed, the level of concentration, attractiveness and excusive experience will be falling. Thus, the innovative approach of learning Chinese with the robotic progressive assessment that tailored with students' learning performance is well recognised. Reducing gap between students with different ability level is considered as a positive effect in learning engagement (Carini, Kuh and Klein, 2006). Such thoughtful redesign Chinese language learning with challenge levels has the potential to provide opportunities for the shortage of Chinese teachers and to develop personalised learning experiences. In addition, Beijing Municipal Commission of Education launched the "Advanced Innovation Center Construction Plan of Higher Education in Beijing", China to drive AI Tutor research through an AI transformation of Beijing public education (UCL Knowledge Lab, 2017). This research is aligned with the innovation and novelty of the national initiatives.

4.2 Interactivity
With the use of a cute, walking and talking robot, students are engaged to learn and participate in the learning interactions:

> *"I like NAO teaching assistant because it is quite interactive."*

"Yes, it is very cute and funny"   "Yes, it's very fun!"
"Yes. It's cute and will attract students to know more about Chinese language."

The Robot Chinese Language tutor is programmed to automatically calculate the students' performance by analysing the voice input of Chinese pronunciation. Please see the following figures for the data sample of live pilot results for two students who took the Learning Colour and Poetry lessons with intelligent progress assessment:

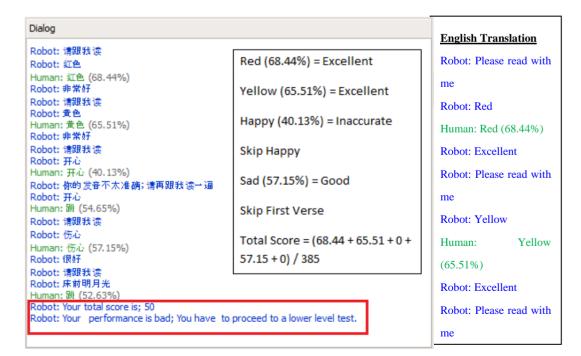Fig. 5. First case - Above Average Learning Performance

Fig. 6. Second case – Below Average Learning Performance

4.3 Motivation and Interest

Through the interactivity, students' engagement and motivation are enhanced by introducing NAO Robot in the language learning experience. Responses from the research participants show that all students find it (1) easy to interact with NAO, (2) useful to learn Chinese with NAO Robot and (3) very interesting when learning Chinese with NAO Robot. None of them provided a negative results for the above three dimensions. For examples:

"It's fun and very innovative. Chinese words are easy to be remembered."

"Able to learn the pronunciation of Chinese language".

"Encourages the student to learn proper Chinese by the poem and engaging them in an interesting session."

"Interesting way of learning Chinese."   *"Yes, it is very interesting."*

The real-time personalised assessment and feedback for the Chinese lessons are impressive and fun. All responses depict the positive poles of engagement in the aspect of emotion and cognition as shown in Table 2:

	Positive engagement	Non-engagement	Negative engagement
Behavioural	Attends lectures, participates with enthusiasm	Skips lectures without excuse	Boycotts, pickets or disrupts lectures
Emotional	Interest	Boredom	Rejection
Cognitive	Meets or exceeds assignment requirements	Assignments late, rushed or absent	Redefines parameters for assignments

Table 2. Poles of Positive and Negative Engagement (Trowler, 2010)

4.4 Challenges and Recommendations

There are limitations to the research such as NAO's speech recognition is poor in a noisy environment. Most participants assert that the voice recognition and noise filtering must be improved for various accents. Psychologically, students might feel difficult to interact with NAO robot if this is their first time speaking with a humanoid robot. Therefore, a user manual guide needs to be provided. NAO might not understand what the students or lecturers say if their pronunciation is inaccurate or their voice is unclear. Thus, NAO should be able to react to the users and ask them to repeat their words. NAO can only recognise one voice at a time. If there are multiple voices at once, he cannot interpret the voice correctly and hence, causing voice recognition problem. Wireless Internet connection is also another major constraint. NAO cannot connect to the institutional Wi-Fi due to limited access and constraint proxy setting. NAO will react slower and its voice recognition will become less accurate if the Wi-Fi connection is weak. Hence, it is important to have a strong Internet connection to connect NAO with the computer that controls it. In addition, it takes time to load the Chinese educational program into NAO (3-5minutes for this research project). These constraints would lead to the practicality of a mass implementations for robot teaching assistants across educational institutions, unless the technology of robotic hardware can further advance.

Ethical issues such as displacement in the teaching labour market in the coming decades and underestimating and under-preparing for AI's impact could results in major societal

disruption and lost opportunities for shared economic and social gains (Future of Humanity Institute, 2017). Thus, we would suggest that the government should call for regular consultations with stakeholders in all industries and expert groups to iteratively establish education and labour policy for robotic teaching assistant, for instance, (1) upskilling for current teaches to use and control educational robots; and (2) to introduce robot tax to fund support for or retaining of educational workers put out of job by robots (Chew, 2017).

Enhancing the model from Next Wave of Learning with Humanoid Robot (Chua and Chew, 2015), these are the proposed principles for Teaching the Chinese Language with a Humanoid Robot in this study:
  (1) Developing the interpreter for the rules [inference engine]: recognizes voice-to-text and executes a rule-based system whose conditions to let NAO understand the conversation.
  (2) Developing the Rule-based: Sample of algorithm, Activity Diagram & Description of Design
  (3) Developing the NAO Chinese language education program for personalized progress results records, robot-human interactivities enhancement with age & emotion analytics for happiness in learning engagement.

5. Concluding Remarks and Future Work

With the invention of robotic technologies in the 21st century, innovation in education using intelligent robots has become a challenging but transformative research in design and implementation. There is clear resistance to the acceptance of robots in educational contexts due to the cost of robots, limited commercialised robotics apps in curricular activities, and the lack of training of educator (Johal, Castellano, Tanaka et al., 2018). By thoughtfully embedding NAO robot into teaching basic Chinese language, this research demonstrates an inquiry case study of AI design principles and learning engagement with humanoid robot teaching assistant. This state-of-the arts robot would be able to use its emotion recognition and body language automated (LED eye with various colours) to demonstrate the Chinese words, to increase learners' understanding and enhance their memory of the words learned. The responses conclude that the novel learning experience is more fun and interesting, thus the engagement from the axis of novelty, interactivity, motivation and interest is enhanced.

The learning engagement paradigm has shifted from manual engagement to personal response systems or mixed-reality on mobile platforms, and now with the humanoid robot, NAO as a Chinese Language Tutor. With the invention of robotic technologies, innovation in education using intelligent robots has become a challenging but transformative research in design and implementation. There are experimental results indicating that students were motivated by educational robots than a traditional learning system (Chin, Hong and Chen, 2014; Mcgill, 2012). We believe that the next wave of learning innovation no longer lies at mobile learning but, a thoughtful integration of face-to-face learning with humanoid robot teaching assistant. The future work is to expand the innovation of user experiences for both students and educators. The level of learning engagement, both emotional and behavioural, enhancement or disruption of independent learning for a larger scale and diversity of research participants will be explored. The use of techniques such as Bayesian knowledge tracing is recommended (Schodde, Bergmann and Kopp, 2017; Zhuhadar, Marklin, Thrasher

and Lytras, 2018). The blending of the proposed results with the depth manipulation can be another novel future direction (Walkington and Bernacki, 2019). Further collaboration with social linguistics expert for designing language-teaching corpus is recommended for the next step.

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Appendix 1: Video demonstrations

NAO Robot -student Colour and Emotion Lesson:
https://bit.ly/2SxtAOO
https://bit.ly/2tKXfeS