# Smart Learning Partner: An Interactive Robot for Education

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**Abstract.** Driven by the latest technologies in artificial intelligence (e.g., natural language processing and emotion recognition), we design a novel robot system, called smart learning partner, to provide a more pleasurable learning experience and better motivate learners. The self-determination theory is used as the guideline to design its human-robot interaction. The large-scale deployment of SLP in local schools and families would bring both research and commercial opportunities.

## 1 Introduction

Different from the formal education and massive open online course (MOOC) platforms that mainly provide standard courses and learning resources, today's education more emphasizes on providing intelligent and personalized learning services for individual learners. Driven by the fast advancements in AI techniques, typically including natural language processing and emotion recognition, the robot industry for education, especially for K-12 education, significantly grows to satisfy the increasing demands for both schools and families in recent years.

The existing educational robots, in general, can be divided into two categories. The first one, providing teachers' manipulative tools for students' learning of scientific knowledge and skills, has been widely used in STEM (Science, Technology, Engineering and Mathematics) courses [1]. The second category mainly belongs to socially assistive robotics [2], which assists learners through their social interactions and daily activities.

In this paper, we introduce a novel robot, called smart learning partner (SLP), which adopts the self-determination theory(SDT) [3] as the design principle to provide a more pleasurable learning experience and better motivate learners during their interaction with the robot. Specifically, it provides the personalized learner-robot interaction services by leveraging on the latest techniques, typically including the conversational agent, question-answering system and emotion recognition. Different from most socially assistive robots targeting on pre-school or primary school students, the SLP robot mainly works as a learning assistant for secondary school students.


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## 2 System Description

From the perspective of system design, the SLP system can be simply divided into two modules, namely *learner interactive module* and *data aggregation module*, as illustrated in Fig. 1. We will elaborate the two modules respectively.

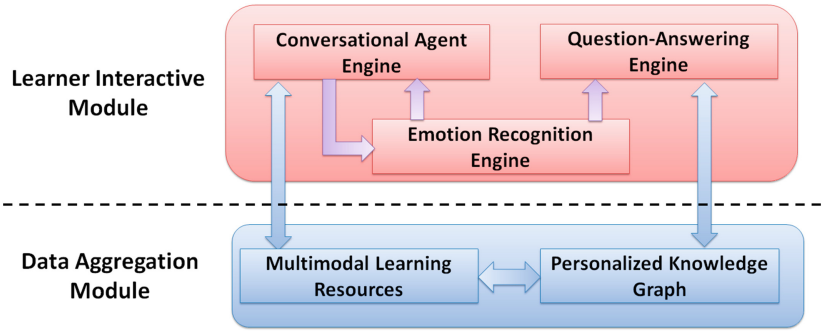



**Fig. 1.** The block diagram of SLP system

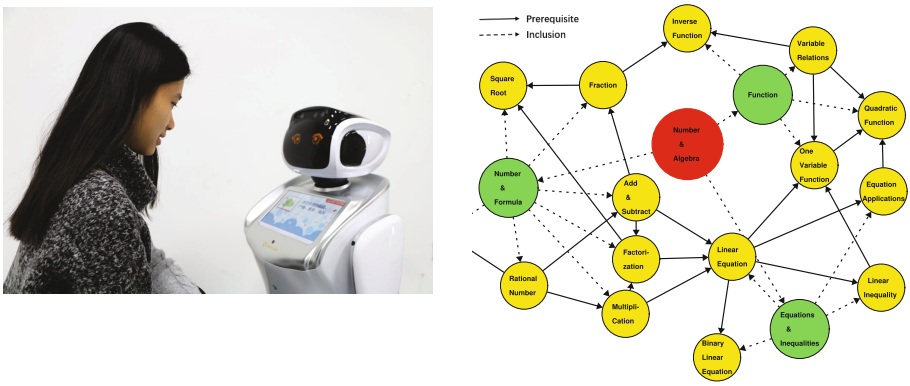
### 2.1 Learner-Robot Interactive Module

This module is the core of the SLP system, as it is mainly in charge of the learner-robot interaction. As mentioned earlier, SDT theory is used as the key design principles. Briefly speaking, SDT is a theory of human motivation and personality that highlights the importance of human inherent growth tendencies and innate psychological needs, typically including *autonomy*, *competence* and *relatedness*. The satisfaction of such psychological needs may effectively motivate learning process, incentivize learners, and eventually enhance their learning performance and achievement. In accordance with SDT, a number of strategies can be implemented and have been successfully applied in designing e-learning tools [4,5]. Similarly, we utilize such three psychological needs to design the module as below:

– ***Autonomy***: it refers to the sense of volition or willingness when doing a task. Normally, choice, acknowledgment of feelings and opportunities for self-direction allow people a great feeling of autonomy. To satisfy a learner's autonomy, a dedicated question-answering (QA) engine is designed based on individual learner's personalized knowledge graph to generate questions and answers. Meanwhile, it provides multi-modal learning resources (e.g., videos and slides) for learners to choose. Figure 2(a) shows the SLP playing a micro-lecture video on the topic of factorization, and Fig. 2(b) demonstrates part of the corresponding learner's personal knowledge graph for mathematics subject. Moreover, by leveraging on the foreground camera on SLP, an emotion recognition engine is implemented to recognize learner's real-time emotion status from his or her facial expression(e.g., happiness, surprise and disgust), where the image-based multiple deep network learning is used [6]. Using such

emotion detection results, we further enhance the interactive module to provide a more appropriate real-time feedback for learners. For example, when a learner keeps showing negative emotions (e.g., disgust) during the learning process, SLP may query about his or her current feelings or directly suggest the learner have a rest to alleviate the pressure.

- ***Competence***: it refers to the need for a challenge and the feeling of effectance. To fulfill a learner's competence, SLP periodically provides positive feedback and incentives when the learner makes a significant progress on the current learning topic. Meanwhile, it tentatively encourages the learner to try a learning topic with a higher difficulty level.
- ***Relatedness***: it refers to the feeling connected with others. To enhance a learner's relatedness to the robot, a dedicated conversational agent (CA) engine is designed to support casual chatting with learners. The designed CA is essentially a computer program which tries to generate human like responses during a conversation. Similar to other end-to-end non-goal-driven dialogue system [7], our CA system is mainly based on the generative probabilistic model. Moreover, we adopt face recognition techniques to automatically identify learner's identity, and accordingly use his or her name and favorite greetings at the beginning of different learning activities.




(a) Micro-Lecture Playing (b) Personalized Knowledge Graph

**Fig. 2.** Personalized knowledge graph supporting question-answering and multi-modal learning resources

Table 1 summarizes the three psychological needs in SDT, design principles and our current implementations for this module.

### 2.2 Data Aggregation Module

As mentioned earlier, our SLP robot targets on the education for primary and secondary school students, and thus it currently supports a number of subjects,

**Table 1.** Design principle and implementation

| Psychological needs | Design principle | Current implementation |
|---|---|---|
| **Autonomy** (The sense of volition or willingness when doing a task) | • Providing choice and meaningful rationales for learning activities<br>• Acknowledge learner's feelings about the current study topics<br>• Minimizing pressure and control | • Question-answering engine with personalized knowledge graphs<br>• Emotion recognition engine with real-time feedback<br>• Multi-modal learning resources |
| **Competence** (The need for a challenge and the feeling of effectance) | • Providing positive comments and reinforcement during the learning process | • Periodically incentivizing learner's significant progress<br>• Properly encouraging learning topics at a higher difficulty level |
| **Relatedness** (Feeling connected with others) | • Conveying a personal, relevant and respectful messages and information | • Conversational agent for casual chatting with learners<br>• Learner identity recognition with personalized greetings and responses |

including mathematics, Chinese, English, history, geography, physics, biology and ideology. For each subject, a personalized knowledge graph can be automatically constructed for each individual learner, according to his or her personal assessment results and the interaction data with the QA engine. For each concept on the knowledge graph, the system automatically denotes different level of the knowledge proficiency for that individual learner using his or her assessment results.

Moreover, the data aggregation module manages a large volume of learning resources. Several types of learning resources are currently available on SLP, including micro-lecture videos, quiz questions, and teaching handouts on the key concepts of each subject. The learning resources will be selectively recommended to learners during their interaction with both QA engine and CA engine. Due to the limited space, we will not elaborate the recommendation algorithm design in this paper.

## 3 Conclusion and Deployment

We introduce our SLP robot system, which emphasizes on the interaction with individual learner and satisfying learners' innate psychological needs. We adopt the SDT as the design guideline, and the latest techniques in emotion recognition, CA and QA systems. We are currently working with the local government agencies to deploy SLP to more than 60 local schools and their students.

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## References

1. Alimisis, D.: Educational robotics: open questions and new challenges. Themes Sci. Technol. Educ. **6**(1), 63–71 (2013)
2. Feil-Seifer, D., Matarić, M.J.: Socially assistive robotics. IEEE Robot. Autom. Mag. **18**(1), 24–31 (2011)
3. Ryan, R.M., Deci, E.L.: Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am. Psychol. **55**(1), 68 (2000)
4. Henkemans, O., et al.: Design and evaluation of a personal robot playing a self-management education game with children with diabetes type 1. Int. J. Hum. Comput. Stud. **106**, 63–76 (2017)
5. Jeno, L.M., Grytnes, J.A., Vandvik, V.: The effect of a mobile-application tool on biology students' motivation and achievement in species identification: a self-determination theory perspective. Comput. Educ. **107**, 1–12 (2017)
6. Yu, Z., Zhang, C.: Image based static facial expression recognition with multiple deep network learning. In: Proceedings of the 2015 ACM on International Conference on Multimodal Interaction, pp. 435–442. ACM (2015)
7. Serban, I.V., Sordoni, A., Bengio, Y., Courville, A.C., Pineau, J.: Building end-to-end dialogue systems using generative hierarchical neural network models. In: AAAI, vol. 16, pp. 3776–3784 (2016)