Enhancing the Well-Being of Seniors: A Teachable Agent for Ikigai

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ABSTRACT

Ikigai, a Japanese term often referred to as "purpose in life" or "the feeling that life is worthwhile", is a commonly used indicator of well-being in studies focused on the elderly population in Japan. It can be identified within the different realms like family, work, and friendship. However, as individuals age, their sense of ikigai is prone to diminish. Teachable agents (TAs) have been employed in educational settings for decades to facilitate learning by teaching students. Previous research has indicated that TAs can have a positive impact on self-esteem which is an important aspect of ikigai. TAs may hold the potential to address issues related to declining ikigai that are often associated with aging. By engaging in the act of teaching the agent, elderly individuals may experience a sense of being needed, consequently enhancing their self-esteem and potentially leading to an improvement in their ikigai levels. In this paper, we introduce a TA designed around the concept of ikigai, aiming at assisting the elderly in maintaining a high level of ikigai to support healthy aging. Based on a user study conducted using the phenomenographical approach, we demonstrate the effectiveness of our proposed TA design.

KEYWORDS

ikigai; teachable agents; human-agent interaction; geriatric care

The Japanese term ikigai is often referred to as "purpose in life", "a reason to live", or "a reason for living"[1–5]. In Japanese studies about the elderly, it is considered to be the most commonly used index of well-being[4, 6–8]. As part of the Active 80 Health Plan[6], the Japanese government encourages a healthy lifestyle and the sense of ikigai among the elderly to live more fulfilling lives. An individual with a strong sense of ikigai enjoys many mental and physical benefits. In addition to extending their life[9–11], ikigai also improves their quality of life and well-being[12]. As the elderly age, they tend to lose ikigai due to factors such as retirement, loss of functional abilities, and loss of family members. Consequently, certain aspects of ikigai may be affected, including self-esteem[13] and self-efficacy[14].

In light of the evidence that teachable agents (TAs) can enhance self-efficacy and self-esteem in education, we used a TA to improve ikigai levels among elderly people in a gerontology study in order to improve the level of ikigai among the elderly. According to the "learning by teaching" theory[15], TAs function by allowing students to teach them and then assessing students' understanding by asking them a series of questions. TAs are widely used in the field of education to help students better learn knowledge. Teaching a TA has been shown to help students improve their self-efficacy[16, 17] and build self-esteem[18], which are important factors in ikigai. The problems of declining ikigai that come with aging may be solved by a TA. As a result of teaching the agent, the elderly may feel that they are needed by someone and that they are still able to help others, leading to a greater sense of self-esteem and satisfaction. These may in turn improve the elderly's ikigai level.

A TA is presented in this paper based on the concept of ikigai to enhance the ikigai level of the elderly so that they can age healthily. Taking a phenomenological approach, we conducted a user study that demonstrated the effectiveness of our proposed TA design.

1 Related Work

1.1 Ikigai

In Japanese, the term ikigai consists of two parts, "iki" which represents "life" and "gai" which represents "worthwhile"[19]. The etymology suggests that this word originally denoted the significance of human life, as well as the social value of a person's life[20].

Many translate and define the term ikigai in English as "purpose in life", "a sense of life worth living", or "a reason to live"[1–5]. Despite the fact that ikigai exists in a variety of translation, research indicates that ikigai should be viewed as encompassing life's meaning, motivations, and values[21, 22].

According to the White Paper on the National Lifestyle released by the Cabinet Office of Japan in 2007, the elderly tend to lose the feeling of ikigai after retirement. Hasegawa and Gashu[23] found that most people are likely to experience at least one of four types of loss, i.e., health, economic base, interpersonal relationships, and life purpose. In addition, research indicated that there is a significant individual variance in ikigai decline[24].

There are many factors which may affect one's level of ikigai. From the perspective of human capital, various studies have demonstrated that physical health and financial status are positively correlated with ikigai[14, 25–27]. A number of studies[25, 26, 28–30] have indicated that social capital variables such as friends, those providing support, and networks among neighbours are important determinants of ikigai. According to Ref. [31], one's sense of purpose in life is not affected by one's role in the home. Instead, it correlates with social roles such as friend, hobbyist, and amateur. Research by Fukuzawa et al.[26] showed that despite declining physical health, one can maintain ikigai by keeping or expanding their social networks. According to Takeda[13], the concept of ikigai is best explained by taking into account self-

esteem, purpose in life, personal energy, and life satisfaction. A four-factor scale was developed and validated to measure ikigai. The deepest and unconscious level of ikigai is self-esteem; the most crucial and fundamental element of ikigai is purpose; personal energy is the most visible and tangible element of ikigai; and life satisfaction is the results of the aforementioned three elements.

As ikigai is a very personal and complex concept, there is a need to take a closer look at the elderly's ikigai and help them maintain.

1.2 Teachable agent

TAs, intelligent agents that can be taught, were introduced in the 1990s. They are pedagogical agents who are based on the theory of teaching-by-teaching, a phenomenon known as the protégé effect[32]. The famous experiment of Bargh and Schul[33] demonstrated that comparatively to students learning for their own benefit, students who are prepared to teach others about paragraph comprehension do better on quizzes about paragraph comprehension than students who prepare to do it themselves. In addition to the benefits related to knowledge, students can improve their self-efficacy[16,17] as well as their self-esteem by working with TAs[18]. As a result of TAs' ego-protective abilities[32], students are prevented from having negative feelings about themselves when they make mistakes, which is believed to prevent them from feeling bad about themselves.

Research on teaching assistants focuses on helping students with school subjects like mathematics, science, and English. To improve the effectiveness of learning, research has been conducted to study the effects of different visuals such as the agent's gender[34–36] and facial expression[37], as well as various communication styles the agent adopts[38–40]. There has been little, if any, study of the impact of tutoring on people of other ages, including the elderly. If TAs are utilized to help the elderly's learn health-related topics, not only may the elderly feel more motivated to learn new things, but their self-esteem and self-efficacy may also be well-protected, and their ikigai may also increase.

2 Proposed Architecture

The proposed TA is defined by starting with a basic definition of a generic agent system. Franklin and Graesser[41] described an agent as a system placed within an environment, interpreting that environment, and acting on that environment to achieve its own goals and modify what it perceives in the future.

Based on this definition, we define:

Definition 1 (Teachable agent for improving ikigai) A teachable agent for improving ikigai, TAII, is a tuple $\text{TAII} = (E, \text{Et}, K, R, A)$, where

E is the set of environment that an agent interacts with;

Et is the set of perception states or events that the agent perceives from the environment;

K is the set of knowledge that the agent learned;

R is the set of reasoning mechanisms employed by the teachable agent;

A is the set of actions that the agent takes.

Definition 2 A set of reasoning mechanisms, R, is a tuple, $R = (\text{As}, \text{Tr}, \text{Pr})$, where

As is the ikigai assessment reasoning which enables the agent to evaluate the person's level of ikigai;

Tr is the teachability reasoning which enables the agent to learn new knowledge;

Pr is the practicability reasoning which enables the agent to

practice the knowledge learned.

The architecture for the proposed TA for improving ikigai is shown in Fig. 1.

The proposed model enables the agent via three primary types of tasks, which are repeated and form three running cycles, namely, assessment cycle, teaching cycle, and practicing cycle.

• **Assessment cycle:** $\text{EtAs}(KA)$

Perception: The agent perceives the environment. For example, a new user interacts with Akeso.

Reasoning: The agent selects a suitable reasoning accordingly. For example, there is a new user and there is no information about the user's ikigai level in the knowledge base, the ikigai assessment reasoning is selected. The agent determines the appropriate assessment question to evaluate the person's level of ikigai.

Knowledge base: The agent receives user responses and stores them into the knowledge base.

Actions: The agent assesses elderly's ikigai level according to the situation.

• **Teaching cycle:** $\text{EtTr}K$

Perception: The agent perceives the environment.

Reasoning: The agent chooses an appropriate reasoning. If the user agrees to teach the agent, the agent learns the knowledge taught through teachability reasoning. It interprets the knowledge into knowledge representations.

Knowledge base: The agent stores the interpreted knowledge representations into the knowledge base.

• **Practicing cycle:** $\text{EtPr}(KA)$

Perception: The agent perceives the environment.

Reasoning: The agent chooses a suitable reasoning accordingly. For example, the agent already learned some knowledge from the user, the user chooses to start to ask questions to test the agent, and the practicabilty reasoning is selected. According to its knowledge, the agent chooses the relevant answers to the user's inquiries.

Knowledge base: If the response is pre-determined, the agent retrieves it from knowledge base.

Actions: The agent responds according to the user's query.

2.1 Ikigai assessment

The four-factor ikigai scale[13], a psychometric tool comprising twenty-eight items, is used to determine the user's level of ikigai. In order to explain the concept of ikigai, four factors are considered the most appropriate: self-esteem, purpose, personal energy, and life satisfaction. The four elements are arranged in such a way that they reflect a person's level of consciousness[13]. As such, we define:

Definition 3 (Individual's ikigai level) An individual's ikigai level, IKIGAI, is a tuple $\text{IKIGAI} = (\text{Se}, P, \text{Pe}, \text{Ls})$, where Se, P, Pe, and Ls are the set of ratings of items on "self-esteem", "purpose in
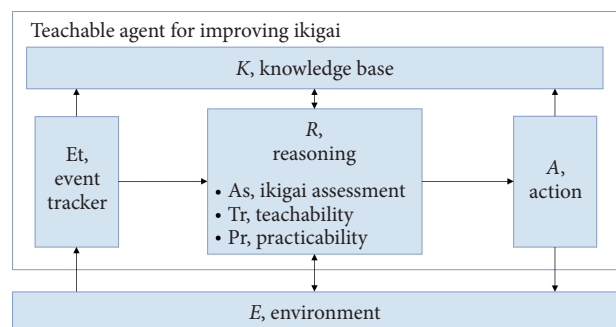

Fig. 1 Teachable agent for improving ikigai architecture.

life", "personal energy", and "life satisfaction" in the four-factor scale, respectively.

On a five-point scale, ikigai is assessed by evaluating whether or not one agrees with each of the twenty-eight items (1 = strongly disagree and 5 = strongly agree). A person's ikigai level is the sum of ratings of all the 28 items in the scale. Below are some example statements from the scale:

(1) I have a lot of goals. (Purpose)

(2) I am satisfied with my current life. (Life satisfaction)

(3) I believe I am an irreplaceable person for my family and friends. (Self-esteem)

(4) I am energetic when working. (Personal energy)

2.2   Knowledge teaching and practicing

Google's use of knowledge graphs for its search engine[42] has prompted a lot of interest in the concept. Providing semantically organized information has significant potential for the development of more intelligent machines[43]. This trait offers many potential solutions for question answering, information retrieval, and recommendation. As with the current question-answering (QA) system, semantic representations of knowledge can be used to build queries and statements to test a user's understanding. It is important for the agent to be aware of possible misunderstandings that users may have regarding a certain concept in order to react accordingly.

To help the agent, a knowledge graph of the concept to be taught is pre-stored in the knowledge base. When the TA learns from a user, it checks its knowledge with the knowledge graph's "correct answers". In order to determine whether the user understands a particular concept, the agent generates questions regarding the concept if it perceives there is a misunderstanding. When the user does not understand the knowledge, a tailored message explaining the negative effects of taking actions according to what the user has taught will be sent to them. This is to hint him that he misunderstood the concept and he probably needed to revisit it.

3   Modelling with Goal Net

A TA senses, reasons, and acts in its environment throughout its lifetime. The agent's main routine is a repeated cycle, which can be modeled with Goal Net[44, 45], a goal-oriented agent modeling method. By doing so, TAs can take a proactive approach to assessing the elderly's ikigai level, learning from them about new knowledge, and practicing the knowledge they have learned. The Goal Net is made up of nodes that represent states that the agents must complete to reach their goal. In a Goal Net model, arcs are shown as arrows connecting various goal states. Transitions, which specify what tasks the agent must do before moving to the next goal state, are represented by vertical bars.

Figure 2 illustrates the main routine of the Goal Net for the proposed TA. As long as the agent pursues its goal, the main routine continues to run. In each cycle, the agent looks for an event update. After the event has been detected, the agent selects the appropriate reasoning. At the end of each cycle, the agent goes back to its initial start node to begin a new cycle. A main routine consists of three sub-goals: assessment, learning, and practice.

In Fig. 3, the Goal Net model is shown for the example sub-goal of practice. The agent begins the sub-goal of practice by posing a question based on its understanding of the knowledge to the user. As a result, the agent may make erroneous statements or take actions that pose a health risk when it misinterprets the knowledge or is incorrectly instructed by the user. It simulates the agent's ability to reflect on and apply the knowledge that it has acquired by providing feedback on the user's instructions. Depending on whether the user corrects them, the agent will execute the correct or incorrect solution. If the agent executes an incorrect solution event, the user will have to teach it again in the following cycle of the agent's Goal Net. If the agent consistently implements the incorrect solution, the agent will respond with the appropriate information to let the user know what is wrong with the concept.

4   User Study

In this study, we employed the phenomenographical method to conduct a qualitative analysis on how different users experience and interact with our proposed teachable agent. This approach places a strong emphasis on delving into the intricate nuances of participants' encounters, aiming to unearth different meaningful patterns within their subjective experiences and emotional responses to the phenomenon under investigation[46]. Typically, ten to fifteen participants will be able to provide a reasonable amount of different viewpoints[47] for phenomenographical analysis. We conducted a 1-month user study with 12 senior participants recruited by a crowdsourcing platform. The
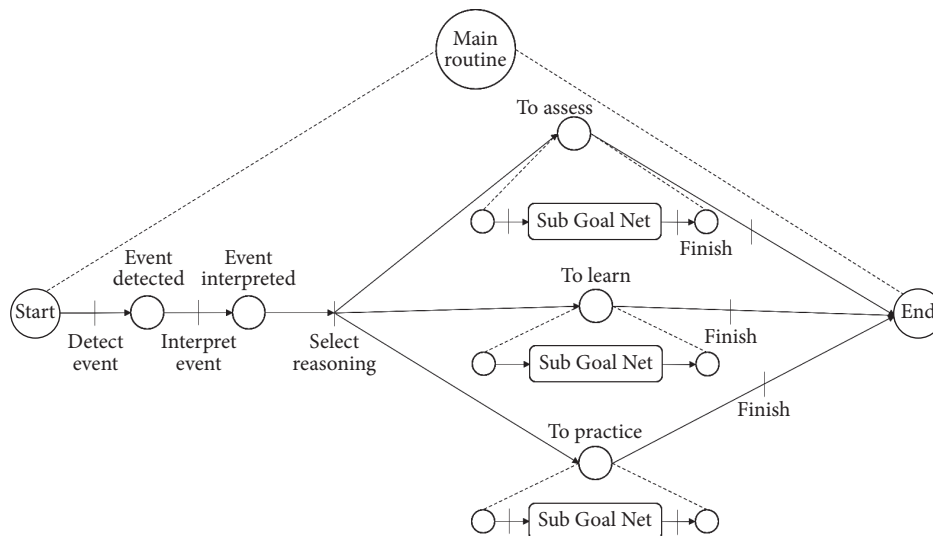

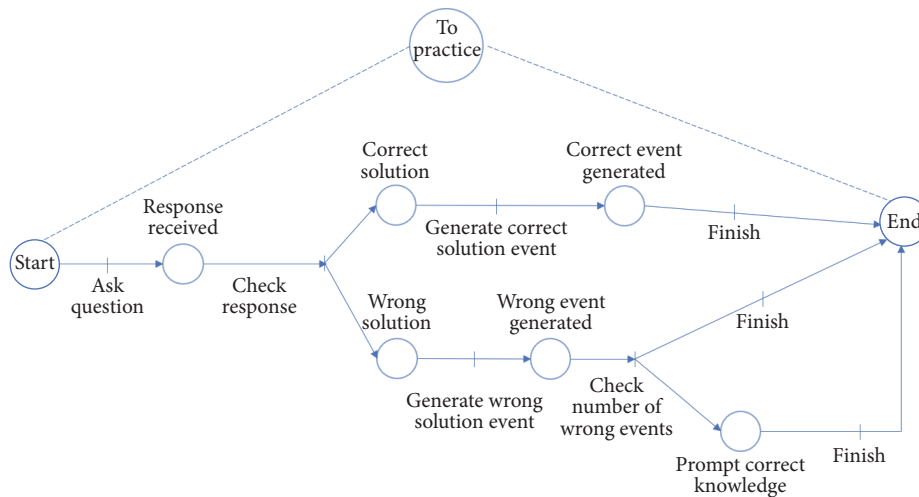**Fig. 2   Goal Net model for the proposed TA's main routine.**

Fig. 3   Goal Net model for the proposed TA's practice sub-goal.

participants aged from 55 to 68 (*n*=12, mean=62.33, and standard deviation=3.41). Nine of them are female while the other three are male. They are all Chinese ethnically. None of the participants is suffering from any chronic diseases or mental health problems. The before and after ikigai level is assessed by the four-factor scale[13] through the assessment reasoning of the teachable agent. During the study, the users communicate with Akeso every day for at least 3 times per day for 1 month. Akeso was playing the role of a student who needs help to recognize the nutrition facts of food to keep a healthy lifestyle. She asks the participants questions such as "Should I take only fruit for dinner to lower my body weight?" The participants teach her the knowledge based on answering her questions. They can also start a conversation by themselves. The conversation text and behaviors of the participants were recorded for analysis. The flow of conversation is shown in Fig. 4.

The study has been approved by the Institutional Review Board.

After the experiment, a semi-structured interview is followed to understand the experiences of Akeso of the participants. We determined the interview outline by literature review on ikigai and

Fig. 4   Akeso conversation flow.

pre-interview results in a pilot study involving 2 researchers from other research groups of our lab. The main interview questions posed to the participants are the following: (1) What are your thoughts and feelings about communicating with Akeso? (2) How do you feel when you learned some knowledge from this study? (3) What has changed in your behavior or perception of a healthy diet after the experiment? (4) What are your thoughts and plans about your future lifestyle?

The one-to-one interviews were conducted online via Tencent Meeting. The interview content but not any images of faces or voices of the participants was recorded and kept strictly confidential. For each participant, the interview took 30–45 min.

After the interview, the researchers transcribed and analysed the contexts by phenomenological analysis approach. Two researchers went through the transcripts independently to code their experiences. Based on the raw materials, we discuss and define the themes by summarizing the homogeneity essences.

Rooted in the analysis of the interview materials, we explored the users' experience of using Akeso as a teachable agent to enhance their ikigai. We summarized 4 themes as follows:

Theme 1   Feeling of the fullest of life

All of the participants experienced a significant feeling of the fullest of life during their communication with Akeso. At the early stage, they expected Akeso's massages to bring them "something to do". They considered answering Akeso's questions as a riddle game which brought some challenges and new insights into their lives. As the experiment progresses, they ask questions to Akeso actively and explore further knowledge according to their daily debate. These behaviours generated from the communication with Akeso fulfil the perception of living of the participants.

Theme 2   Feeling of being needed

The majority of our participants (10 of the 12) believe Akeso is a human being instead of artificial intelligence. They consider her as a polite and studious young lady who needs some help from the seniors. After several days of communication, when they became a little familiar with each other, in the perception of the participants, they tend to teach Akeso and correct her behaviours and beliefs proactively. When Akeso thanks their advice, the participants feel happy and satisfied with the feeling of being needed by others. They were engaged not only in the communication in this study but also exploring more knowledge through their willingness of helping Akeso.

Theme 3   Feeling of emerging a goal in life

Seven of the participants showed a significant tendency to change their dietary habits according to their teaching and
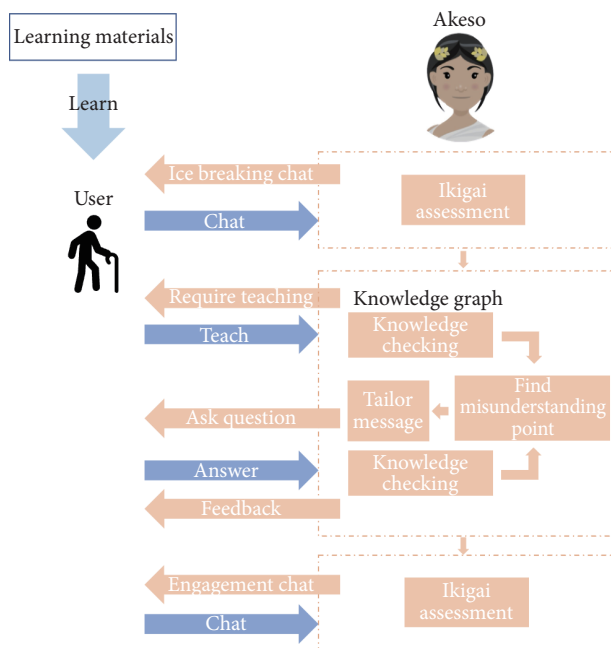
learning of nutrition knowledge with Akeso. They practised their knowledge by simulating Akeso's behavior by sharing a photo of each of their meal to ask for a nutrition evaluation. They tend to plan their meals following the new knowledge gained from this study. They also attempt to share their knowledge and lifestyle with their families and friends. During the interview, these participants mentioned that "I need to learn more nutrition knowledge and improve the meals for my family." and "I cannot wait to share the knowledge with my sister. I need to help her from her terrible high-sugar diet." This kind of new goal of life is generated during the communication with the teachable agent.

Theme 4   Feeling of strengthening self-esteem

Nine of our participants highlighted their feelings of self-esteem enhancement after the study. One of them said: "I was always wrong at the beginning. The first time when I found Akeso's meal was low in protein. I figured it out without any confidence. Unexpectedly, Akeso confirmed my opinion and thanked me. At that moment, I feel I am the wisest person in the world." Some other participants expressed similar feelings with more dramatic descriptions like "I have been ignored in my family and in my social circle for quite some time. Nobody cares about my opinion because I know nothing in their minds. By teaching Akeso, I felt even my voice is getting firm."

5   Conclusion

This research proposed a teachable agent design with concept to be taught represented in a knowledge graph to increase the ikigai of senior populations with the aim of enhancing the public well-being of an aged society. The study, employing a phenomenological approach, demonstrated the efficacy of this framework in enhancing ikigai in seniors across four dimensions: enhancing a sense of fulfillment, fostering feelings of being essential, stimulating life goals, and reinforcing self-esteem. Future research avenues could encompass a longitudinal study to evaluate the enduring impact of this intervention on elderly participants. Additionally, integrating large language models (LLMs) could significantly personalize the teachable agent. This enhancement would allow the agent to engage in more meaningful conversations, offer companionship, and provide customized feedback, further nurturing the seniors' sense of purpose and connection.

Dates

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