A Literacy Education Model with Commercial Video Games to Address Digital Divide Problem

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***Abstract*—We propose an innovative Literacy Education Model to address the digital divide problem in contemporary society, focusing on enhancing human literacy through the use of commercial video games and the automatic generation of educational materials. The human literacy model, fundamental to our approach, consists of three layers: the Application layer, the Method layer, and the Concept layer. Each layer is characterized by a specific skill: operation skill in the Application layer, knowledge acquisition skill in the Method layer, and generalization skill in the Concept layer. Our proposed Literacy Education Model is built upon this three-tiered human literacy model and includes a curriculum developed through a six-step process. A distinctive feature of our Literacy Education Model is the integration of commercial video games, which serve as engaging educational tools, and the use of OpenAI API like the Chat-GPT for the automatic generation of educational materials. We developed a rudimentary literacy education tool based on the models. Subjects tried taking the literacy education with the tool in preliminary experiments. We observed a progression as the individual improved their literacy skills and knowledge.**

***Keywords*—literacy education, human literacy model, getting skills and knowledge, information-poor, commercial video game**

I. Introduction

In contemporary society, the digital divide has emerged as a significant issue. Disparities in access to information technology have led to pronounced differences in individuals' economic and social well-being, categorizing them as either "information-rich" or "information-poor" [1–4]. It is imperative for individuals who are "information-poor" to receive IT literacy education to harness the benefits of modern information technology. However, certain demographics, such as the elderly, often face challenges, including not only a lack of familiarity with technology but also a resistance to adopting it. In addition, recent digital literacy education is not sufficient not only for elders but also for various generations of students, especially the total education process with IT literacy maturity levels [5, 6].

To address the digital divide, this paper proposes an innovative Literacy Education Model that incorporates the use of commercial video games, including those available on platforms such as Nintendo, PlayStation, and PC. The rationale for focusing on commercial video games lies in their accessibility and cost-effectiveness, as well as the diversity of games available. This diversity ensures that various groups, including the elderly, can easily buy and engage with different games.

At first, we developed a novel human literacy model that facilitates the understanding of new digital devices and software. This model is informed, in part, by concepts derived from artificial intelligence models [7]. Establishing this human literacy model allows for a more precise delineation of the scope of our literacy education initiative.

Subsequently, preliminary experiments were conducted to explore how individuals can acquire skills and knowledge related to digital devices and software through engagement with commercial video games. The findings of these experiments were instrumental in constructing a framework for skill and knowledge acquisition. This framework elucidates the patterns and processes through which individuals can learn effectively.

This paper presents the human literacy model, outlines the scope of our literacy education initiative, discusses the preliminary experiments, and describes the developed process for acquiring skills and knowledge through the use of commercial video games. After that, we propose a comprehensive Literacy Education Model building upon this process that employs commercial video games as educational tools.

Related works are shown in Section II. Section III shows a basic idea including a new human literacy model, the scope of our literacy education. Section IV shows a new Literacy Education Model based on results of preliminary experiments and a process of getting skills and knowledge with commercial video games. Section V shows a part of implement and evaluation of the model. Section VI shows summary and future research.

II. Related Works

There is a substantial body of research exploring education through Game-Based Learning (GBL). Babar, for example, investigated teachers' attitudes towards barriers in implementing GBL in the context of English as an additional language (EAL) [8]. He identified lack of time, resources, and alignment with students' preferences as key challenges. Conversely, Fabienke and colleagues illuminated how children acquire English literacy through a digital game, My Reading Academy [9]. This study particularly emphasized reading and pronunciation skills among young learners, demonstrating the efficacy of game-based learning in this context. However, these investigations differ from our own in that they predominantly focus on English language literacy education, whereas our research aims to develop a more generalized model for literacy education.

In another study, Liu and collaborators explored cyber

wellness literacy, learning motivation, and digital game engagement among middle school students [10]. Their findings supported the effectiveness of GBL in enhancing cyber wellness literacy, among other outcomes. Additionally, Literat *et al*. reported the successful implementation of a digital game-based course in a middle school to foster news literacy education [11]. These studies, however, primarily target school education, which is confined to specific settings and audiences (i.e., students). In contrast, our research embraces a broader scope, seeking to serve a wider demographic that includes not only young learners but also the elderly and the general public.

III. Human Literacy Model

A. Basic Idea

Fig. 1 illustrates the Human Literacy Model designed for literacy education, which is structured into three distinct layers.

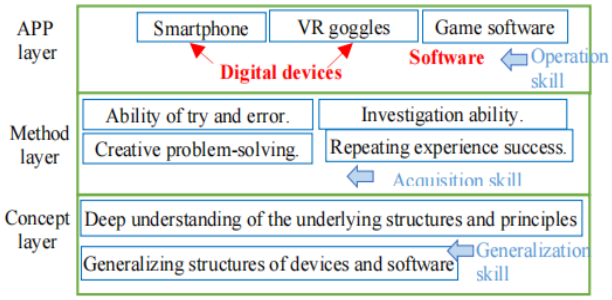

Fig. 1. A human literacy model.

- Application Layer (App Layer): The first layer, referred to as the Application Layer or "App Layer," is centered around imparting operational skills. These skills are fundamental in literacy education and include the ability to effectively use various devices and software. It is important to note that the nature of operational skills is contingent on the specific devices and software in question.
- Acquisition Layer: The second layer is focused on acquisition skills. These skills encompass the ability of individuals to learn and understand the operation of new devices and software autonomously. This means that even in the absence of explicit instruction, individuals can acquire operational knowledge through trial and error, creative problem-solving, or researching online. These capabilities are collectively referred to as acquisition skills.
- Generalization Layer: The third and final layer is the Generalization Layer, which is associated with a deeper understanding of the underlying structures and principles of devices and software. By comprehending the foundational elements and core functionalities of devices and software, individuals can achieve generalization skills. This layer of skill is crucial for enabling the extrapolation and application of knowledge across different contexts and technologies.

The Human Literacy Model, with its three-layered structure, serves as a comprehensive framework for literacy education. By progressing through these layers, learners are able to not only operate devices and software but also independently acquire new skills and apply their knowledge in a generalized manner.

B. Our Scope of Literacy Education

Traditionally, literacy education within the field of computer science has predominantly focused on the Application Layer, emphasizing "Operation Skills." However, in light of the rapid pace of technological innovation in contemporary society, our approach to literacy education encompasses all three layers of the Human Literacy Model.

This broader focus is imperative for fostering adaptability and continuous learning among individuals. For instance, if individuals master the use of VR goggles one year, they may find that new and advanced VR goggles are released the subsequent year. Furthermore, within a short span, VR goggles could potentially be supplanted by AR glasses. Such rapid technological evolution necessitates literacy education that goes beyond basic operation skills.

Consequently, we advocate for the inclusion of the Acquisition and Generalization Layers in literacy education. Mastering the Acquisition Layer enables individuals to independently learn and adapt to new technologies. Proficiency in the Generalization Layer empowers individuals with the ability to understand underlying principles, which facilitates the application of their knowledge to emerging technologies.

By adopting a comprehensive literacy education approach that integrates all three layers of the Human Literacy Model, individuals are better equipped to keep pace with and adapt to the ever-evolving technological landscape.

IV. Literacy Education Model for Digital Divide

A. Overview of the Development Process

The development of the Literacy Education Model is undertaken through a systematic five-step research process.

- Step 1: Creation of the Human Literacy Model—The initial step involves the formulation of the Human Literacy Model, which serves as the foundation for the education model (refer to Section II for a detailed discussion).
- Step 2: Preliminary Experiments with Commercial video games—This step involves conducting preliminary experiments employing commercial video games to investigate their efficacy in facilitating skill and knowledge acquisition.
- Step 3: Development of a Process for Skill and Knowledge Acquisition—Here, based on the insights gained from the preliminary experiments, a process for acquiring skills and knowledge is developed.
- Step 4: Development of a Comprehensive Process for Acquiring Competencies Across the Three Layers of the Human Literacy Model—This step entails refining and expanding the process developed in Step 3, utilizing the results of the full-scale experiments, to ensure it effectively addresses all three layers of the Human Literacy Model.
- Step 5: Formulation of the Literacy Education Model—Finally, the data and insights gathered through

the preceding steps are synthesized into a coherent Literacy Education Model.

B. Step 2: Preliminary Experiments with Commercial Video Games

The primary objective of the preliminary experiments is to elucidate the mechanisms through which individuals acquire skills and knowledge [12]. The preliminary experiments have been structured as follows:

1) Game Utilized: The management simulation game "Little Big Workshop" [13] was selected for use in these experiments.
2) Participants: A total of 17 participants were involved in the experiments, all of whom are students.
3) Examinations: Participants were required to take examinations assessing their knowledge and skills related to the game at various intervals.
4) Flexibility in Participation: Participants were allowed the flexibility to play the game and take the examinations at any time, with no restrictions on the number of attempts.
5) Examination Results: Participants were not provided access to the results of their examinations.

This setup was designed to rigorously analyze and understand the acquisition of skills and knowledge in a controlled environment.

None of the participants were familiar with the game "Little Big Workshop" prior to the experiment. Consequently, all participants were faced with the dual challenge of navigating the operational complexity of the game and devising strategies to succeed in the management simulation.

The results of the preliminary experiment are presented in Fig. 2. The x-axis represents the playtime, reflecting the total duration for which participants engaged with the game, while the y-axis represents the maximum scores achieved in the examinations. A higher score indicates a better understanding of the game's operations and underlying mechanics.

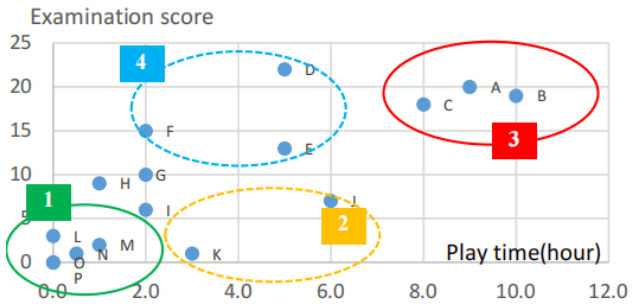

Fig. 2. Results of the preliminary experiments.

For instance, Participant A exhibited a gradual increase in scores commensurate with extended playtime, suggesting a steady acquisition of skills and knowledge through gameplay. In contrast, Participant F attained high scores with relatively minimal playtime, indicating a rapid comprehension and aptitude for the game.

Conversely, Participants L, P, O, N, and M discontinued the game after a brief period of engagement and only took the examination once. The limited playtime and lack of repeated examination attempts suggest that these participants may belong to the "information poor" category, potentially facing challenges in adapting to new technologies and software.

C. Step 3: Development of a Process for Skill and Knowledge Acquisition

Based on the findings from the preliminary experiments, we have classified the participants into four distinct groups as illustrated in Fig. 2.

- Group 1 comprises individuals characterized as "information poor," who displayed a tendency to disengage early on.
- Group 2 consists of individuals who persevered despite not showing significant improvement in their skills or knowledge.
- Group 3 includes individuals who demonstrated consistent efforts and exhibited a steady improvement in their skills and knowledge.
- Group 4 encapsulates individuals who adeptly navigated the game with minimal effort. It is plausible that members of Group 4 are "information rich," possessing proficiency across all three layers of skills delineated in the human literacy model (refer to Section II).

The overarching aim of our research is to facilitate literacy education tailored for Group 1. The optimal outcome is the transition of individuals, such as the elderly, from Group 1 to Groups 2, 3, or 4. Essentially, our literacy education endeavors to elevate individuals from Group 1 to the higher groups.

In this context, Fig. 3 depicts the envisioned progression model for skills and knowledge acquisition in our literacy education framework. The core tenet of this model is the transformation from a lower group to a higher group. To transition from Group 1 to Group 2, individuals need to acquire operational skills corresponding to the App layer of the Human Literacy Model.

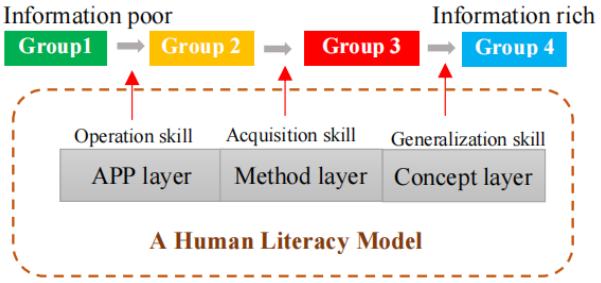

Fig. 3. A process of getting skills and knowledge in our literacy education.

Progression from Group 2 to Group 3 necessitates the development of acquisition skills associated with the Method layer of the Human Literacy Model. Lastly, to ascend from Group 3 to Group 4, individuals must cultivate generalization skills, which are integral to the Concept layer of the Human Literacy Model.

D. Step 4: Development of a Comprehensive Process for Acquiring Competencies Across the Three Layers of the Human Literacy Model

Building on the insights from Fig. 3, we delineate comprehensive processes essential for acquiring competencies across the three layers of the Human Literacy Model. The conceptual framework underpinning this developmental process is illustrated in Fig. 4. Specifically, Fig. 4 demonstrates the development of a comprehensive

process tailored for individuals in Group 1 using a commercial video game, denoted as Game A. For individuals in Group 1, the focus is on acquiring operational skills at the Application Layer within the Human Literacy Model. Central to this process is the "Game A-Group 1 Model," which is integrated into the Chat-GPT engine.

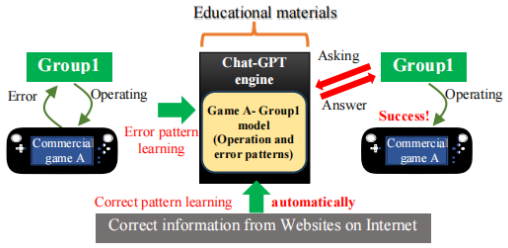

Fig. 4. A concept of developing comprehensive processes for acquiring competencies.

This "Game A-Group 1 Model" is constructed by analyzing the operational behaviors and errors of Group 1 participants, along with learning the optimal operational patterns for Game A, sourced from various internet resources, including global game guides. The "Game A-Group 1 Model" functions as educational content tailored for individuals in Group 1.

Upon completion of the "Game A-Group 1 Model", individuals in Group 1 interact with Chat-GPT by posing questions related to Game A. Chat-GPT, utilizing the "Game A-Group 1 Model", provides hints in response to the queries instead of direct answers. Through gameplay and this interactive engagement with the "Game A-Group 1 Model" via Chat-GPT, Group 1 participants acquire the skills necessary for proficiency in Game A.

A distinctive aspect of this step is the deployment of the Chat-GPT engine. Creating operational educational materials for each game manually would be immensely labor-intensive due to the sheer volume of commercial video games available worldwide. Additionally, finding a definitive solution can be challenging due to the variety of potential pathways available even within a single game. By employing the Chat-GPT learning engine for the automated development of the "Game A-Group 1 Model", this approach offers enhanced convenience and practicality in Step 4.

E. Step 5: Formulation of the Literacy Education Model

Fig. 5 illustrates the framework employed for the development of a Literacy Education Model. Utilizing the "Game A - Group 1 Model," which was constructed in Step 4, we establish a more comprehensive Literacy Education Model. It is important to note that while the "Game A - Group 1 Model" from Step 4 is specifically tailored to one particular group, the Literacy Education Model takes into account all four groups as depicted in Fig. 2.

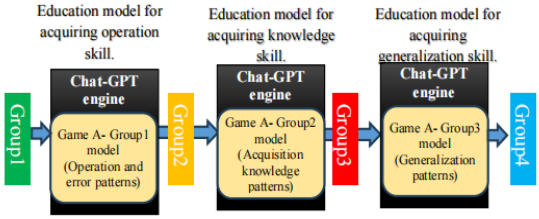

Fig. 5. A literacy education model.

For each of the four groups and for each game considered in Step 4, corresponding "Game-Group Models" are created. The Literacy Education Model is an amalgamation of these four "Game-Group Models", and additionally incorporates a progression pathway that transitions individuals from Group 1 through to Group 4. This holistic model, with its inclusion of the four Game-Group Models and the delineated progression pathway, constitutes the Literacy Education Model we set out to develop.

V. Implementation and Evaluation

As a preliminary approach, we have developed a prototype Game-Group model. The game chosen for this trial is "Pokémon UNITE" [14], and the target group for this implementation is Group 1. However, utilization of the Chat-GPT engine proved to be challenging due to delays in acquiring access permissions for the OpenAI API Chat-GPT4. My account was granted access to the OpenAI API Chat-GPT on July 7th, 2023. Consequently, the "Game-Pokémon UNITE – Group 1 model" was constructed manually by our team. We developed a system consisting of a series of questions, hints, and answers which were incorporated into a website.

An individual belonging to Group 1, as illustrated in Fig. 2, engaged in learning operation skills by utilizing the aforementioned website in conjunction with playing "Pokémon UNITE". The individual consistently interacted with the game and the website, employing questions and hints. We observed a discernible progression as the individual successfully transitioned from Group 1 to Group 2, and subsequently to Group 3.

It is essential to acknowledge that this implementation is rudimentary and the experiments conducted are not extensive. Fig. 6 shows a result sample of subject A in the evaluation. Subject A is a novice of the "Pokémon UNITE", and subject A was categorized into Group 1 in Fig. 2. Although subject A gave up early in the Preliminary Experiments, she did not give up in the evaluation experiment. However, in the early stage of the experiment from 2023/10/20 to 10/30, she did not improve the game scores (the orange boxplot in Fig. 6), and she did not increase the test scores (the green bars in Fig. 6) until 10/28. She took the Chat-GPT materials in the tool on 10/27, 10/28, and 10/29. Her game scores significantly improved on 10/30, her test scores improved from 140 to 230. Subject A continued playing the "Pokémon UNITE" using the tool despite that she was a member of Group 1 who gave up soon. We were able to realize her improvement in her literacy level in the experiment.

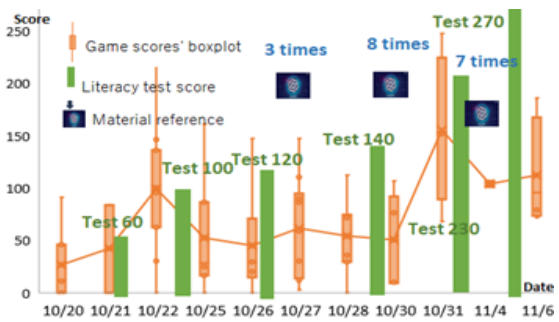

Fig. 6. A result of subject A in the evaluation.

In future endeavors, our primary objective is to construct Game-Group models within the Chat-GPT engine [15]. These models will encompass all four groups and a diverse array of commercial video games. Subsequently, we aim to rigorously evaluate the efficacy of the Literacy Education Model through monitoring the progression of individuals as they transition from Group 1 to Group 4.

VI. Conclusion

In an effort to address the digital divide, this study introduces a novel Literacy Education Model. A distinctive feature of this model is its incorporation of commercial video games, which offers a plethora of options and accessibility as gaming does not necessitate a substantial investment. Initially, we present a human literacy model encompassing three layers. Subsequently, utilizing a commercial management simulation game, "Little Big Workshop", preliminary experiments were conducted to apply the human literacy model. Thereafter, the 17 participants were classified into four groups based on their performance and engagement. With the human literacy model as the foundation and accounting for the categorization of participants, a framework for acquiring skills and knowledge was developed.

Furthermore, we elaborated on the concept of creating comprehensive processes aimed at cultivating competencies. A salient feature of these processes is the construction of Game-Group models within the Chat-GPT engine. The Game-Group models are dynamically generated by assimilating user interactions, mistakes, and integrating gaming guides from various online sources globally. These models are capable of receiving queries from users and providing them with hints.

Once Game-Group models for the four groups, spanning various commercial video games, are established, a comprehensive Literacy Education Model can be constructed to tackle the digital divide. Looking forward, our aim is to implement Game-Group models utilizing the Chat-GPT engine. The Literacy Education Model will be further developed by incorporating an array of commercial video games. Eventually, the model will undergo extensive evaluations through large-scale experiments conducted globally.

To solve the digital divide problem, we propose a new Literacy Education Model. The feature of the model is the usage of commercial video games because there are many kinds of games in the world. Everyone easily plays games without high budgets. At first, a human literacy model is proposed including three layers. Next, based on the human literacy model, we had the preliminary experiments using a commercial management simulation game "Little Big Workshop". After that, the 17 examinees were categorized into 4 groups. Using the human literacy model and the 4 groups, a process of getting skills and knowledge is proposed. In the future, the proposed process of getting skills and knowledge will be evaluated in full-scale experiments. After that, we will propose a new Literacy Education Model with commercial video games based on the process model of getting skills and knowledge.

Conflict of Interest

The authors declare no conflict of interest associated with this manuscript.

Author Contributions

Noriko Hanakawa designed the study, the main conceptual ideas, and the proof outline. Masak Obana collected the data. Noriko Hanakawa and Masaki Obana aided in interpreting the results and worked on the manuscript. All authors discussed the results and commented on the manuscript.

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