

교육용 챗봇 설계 원리 도출: 휴먼-챗봇 상호작용에 관한 실증연구를 토대로

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Deriving Design Principles for Educational Chatbots from Empirical Studies on Human - Chatbot Interaction

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[요 약]

이 연구에서는 교육용 챗봇에 대한 체계적인 연구를 통해 챗봇 설계 시 고려해야 할 원리를 도출하였다. 이를 위하여 교육용 챗봇에 대한 선행연구 분석을 진행하였으며, 분석 결과를 토대로 챗봇의 역할을 고려한 설계 원리를 제안하였다. 선행연구를 토대로 교육용 챗봇의 역할은 크게 튜터, 평가자, 응답자, 중재자, 학습동료로 구분할 수 있었다. 역할별로 고려해야 할 설계 원리를 탐색한 결과, 튜터챗봇은 감성 원리(Live emotion principle), 양식 원리(Modality principle), 외생적 부하 조절 원리(Extraneous principle)를 고려해야 하는 것으로 나타났다. 평가자 역할의 챗봇은 봇 효과 원리(Bot effect principle)를, 응답자 챗봇을 개발할 때는 성 원리(Gender principle)와 양식 원리를 고려해야 한다. 중재자 챗봇의 경우 중립적 감정 원리(Neutral emotion principle)를, 동료 학습자 챗봇의 경우, 양식 원리와 더불어 모방 원리(Imitation principle), 중립적 감정 원리(Neutral emotion principle)를 고려해야 한다. 앞으로는 챗봇의 역할에 따른 콘텐츠 제시 방법과 교육 챗봇의 차별화된 역할에 대한 연구를 더욱 심층적으로 수행할 필요가 있다.

[Abstract]

This study derives design principles according to the role of chatbots through a systematic review of educational chatbots. We propose design principles that should be considered, depending on the role of the chatbot. When designing a chatbot that plays the role of a tutor, it is necessary to consider the Live emotion principle, Modality principle, and Extraneous principle. When designing a chatbot that acts as an evaluator, the Bot effect principle should be considered. When developing a chatbot that acts as a responder, the Gender principle and Modality principle should be considered. In the case of a chatbot that plays the role of a moderator, it is necessary to consider the Neutral emotion principle, and in the case of a chatbot that plays the role of peer learner, the Modality principle (voice), the Imitation principle, and the Neutral emotion principle should be considered. In the future, it is necessary to study the method of contents presentation and the differentiated role of educational chatbots.

색인어 : 챗봇, 챗봇매개학습(CML), 설계원리

Key word : Chatbot, Chatbot-Mediated Learning (CML), Design Principles

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I. Introduction

Chatbots are computer programs that help humans communicate with computers through text or voice interactions. With the proliferation of Massive Open Online Courses (MOOCs) and the widespread use of messaging apps, the need for chatbots in education is increasing. There are three reasons for introducing chatbots. First, customer management costs can be lowered [11]. Second, they can shorten the time within which a response is provided to the customer, can support the service 24 hours a day, and can improve user satisfaction through customized consultation. Third, it is possible to improve the product or service by collecting information about the customer’s needs during the conversation with the chatbot. We may expect the same possibility in the context of education. When using chatbot technology for educational purposes, providing feedback to learners can be made more efficient, and it can be done all the time, increasing learners’ satisfaction. In addition, learning support may be optimized by collecting a variety of information about the learners. However, while chatbot technology is evolving, its integration into education tends to be rather sluggish [1]. There is a lack of research on the design principles to consider when developing an educational chatbot. This study aims to promote the development of educational chatbots by setting out the principles to be considered in designing educational chatbots, based on systematic analysis.

RQ1: How have chatbots been incorporated into empirical studies on human–chatbot interaction?

RQ2: What implications for educational chatbots can be derived from the studies?

II. Theoretical Background

2-1 Expectations and Roles of Chatbots

A chatbot is a computer program to simulate human conversation via text or voice interaction [19]. Other terms for chatbots include talkbots, chatterbots, conversational agents, artificial conversational entities, and a conversational system. Efforts have been made to introduce chatbots or similar technologies in the education field, and related terms include a pedagogical agent or intelligent pedagogical agent (IPA), intelligent tutoring systems (ITS), and Artificial Intelligence Markup Language (AIML) -based chatbot. In the context of technology-mediated learning [2], chatbot-mediated learning (CML) contributes to motivation, self-directed learning, and

individual learning by providing learners with individual learning environments that enhance the learning process and its outcomes. More specifically, chatbots can influence the learner’s learning process – the way in which information is found and communicated. In other words, rather than being provided with the contents passively, learners can support themselves to ask questions and lead the way. Second, learners can effectively support the learning process in large classrooms or in large online courses such as MOOCs. This may contribute to lowering the dissatisfaction experienced by learners and lowering the dropout rate. Third, learners can help them to make the right judgment by providing optimal information at the right time, and can provide continuous feedback to learners / teachers.

표 1. 챗봇 관련 선행연구

Table 1. An empirical study of a chatbot

| Research | Application area | Role of bot | Goal |
|----------|-----------------------|--------------|------------------------|
| [16] | Demonstration | Peer learner | Demonstration Partners |
| [11] | Ideation | Peer learner | Provide peer feedback |
| [20] | Fitness | Peer learner | Fitness companion |
| [7] | Q&A | Guide | Website navigation |
| [10] | Survey | Guide | Record response |
| [15] | Information retrieval | Guide | Search support |
| [22] | Customer service | Guide | Customer Agent |

In general, chatbots are responsible for providing guidance, answering questions, or facilitating specific actions as coaches or colleagues (Table 1). In the educational context, the role of the chatbot can be set in various ways, which can be divided into five roles (see table 2). They are: tutors who guide and support the learning process of individual learners; evaluators who check the learner’s progress and diagnose performance; respondents who answer learners’ questions; communicators who mediate instructors and learners through interaction with learners; and fellow learners who exchange everyday conversations.

표 2. 교육 영역에서 챗봇의 역할

Table 2. Educational roles of a chatbot

| Educational role of chatbot | Details |
|-----------------------------|---|
| Tutor | Provide individual and personalized support |
| Evaluator | Assess learner’s progress and performance |
| Responder | Answer questions related to learning task |
| Moderator | Be a communicating channel between instructor and learner |
| Peer learner | Be an interlocutor for common dialogue and conversation |

2-2 Principles of Chatbot Design

The following should be considered when designing chomps derived from Facebook (bot) [8], interoperability [12], and Microsoft [17] design and development principles.

The principles in table 3 provide guidelines on how to interact with chatbots from the UI or UX standpoint, but do not provide a

standard on the purpose for which it should be used. In order to actively use a chatbot in an educational context, design and development guidelines should be prepared from the viewpoint of teaching and learning.

표 3. 챗봇 개발을 위한 설계 원리의 예
Table 3. Chatbot design principles (example)

| Category | Principles | Source |
|------------------|---|-----------------|
| Consistency | Use the UI components of the chat platform uniformly | [12] |
| | Optimize for all users and usage | [12] |
| Shortening | Support a way to solve problems faster | [17] |
| | Provide button and button-type replies to help quick selection in limited circumstances | [8], [17] |
| Feedback | Minimize the waiting process and make the user aware of the waiting state | [8], [17] |
| | Provide notifications in appropriate situations | [17] |
| Conversation | Organize the flow of words and contexts naturally, and maintain the standards of dialogue | [8], [12], [17] |
| | Ask your questions carefully and check your intentions | [8] |
| | Provide appropriate humor | [8] |
| Problem response | Provide opportunities to respond to failures | [8], [17] |
| | Provide the ability to go back and cancel | [8], [12] |
| Recognition | Let users know clearly how to use chatbot | [8] |
| | Make intuitive awareness of the chatbot's UI components | [8], [17] |

NOTE: [8] Facebook, [12] Intercom, [17] Microsoft

Hints for deriving chatbot design principles can be found in the Conversational Agents (CA) study. Traditional research was mainly on agent support, voice, and appearance (see table 4). The research that is required for the future is empirical and qualitative study of the change due to the agent's participation, and research into the role of the agent.

표 4. 대화형 에이전트의 설계 원리에 대한 연구
Table 4. Research related to conversational agents

| Principle | Contents | Reference |
|---------------------------|---|-----------|
| Personification principle | The learner learns better when the agent is represented by a personalized method rather than a non-personalized method. | |
| Voice principle | The learner learns better when exposed to a human voice method (human-voice method) rather than a machine-voice method. | [4], [13] |
| Image principle | The learner learns better when the speaker's face appears on the screen (image-present method) rather than when it does not appear (no-image method). | |

III. Methodology

In order to establish an empirical ground from which to derive design principles for educational chatbots, we first explored previous chatbot studies and summarized their findings. From there we extracted several implications for a chatbot design that is suitable in an educational context. The review process began by identifying the relevant research papers from Social Science Citation Index (SSCI) and Science Citation Index Expanded

(SCIE) journals, which are of high quality and impact. Conference proceedings and conceptual papers were excluded from the search. Research papers published since 2005 were collected using the keywords “conversational agent”, “chatbot”, “pedagogical agent”, “conversational system”, “dialog system”, “chatterbot”, “chat bot”, “chat-bot”, and “intelligent pedagogical agent”. After the search process, we screened the articles by distinguishing empirical studies that focused on interactions between humans and chatbots. A total of seven studies from six articles were reviewed.

IV. Findings

4-1 Research question 1: How have chatbots been incorporated into empirical studies on human-chatbot interaction?

To answer the research question, we organized the review findings into two sets; one sorted by chatbot feature and the other by research variables and results. Basic information on each study was included in the first set (see table 5). Of the seven studies reviewed, all the researches were conducted under a higher education setting except for that of Corti and Gillespie (2016) [6], which was in an open setting, and that of van der Meij, van der Meij, and Harnsen (2015) [21], at a secondary school. The articles covered target knowledges in a varied range of disciplines such as healthy eating behavior [3], the circulatory system [9], instructional planning [14], and kinematics [21]. The chatbots used in the studies also differed from each other.

The chatbot features examined in the studies were mostly variations of delivery types (or representation types). They included expressions made by chatbots (e.g., facial expression, emotional expression, empathetic expression), the gender of the chatbots (i.e., male and female), modality (e.g., voice, text), and other representation types (e.g., head movement). A few studies incorporated instructional features into chatbots by providing prompts and feedback [9] and motivational scaffolding [21].

표 5. 챗봇의 역할에 따라 구분한 선행 연구
Table 5. Articles reviewed sorted by chatbot features

| Ref. no. | Setting | Participants | Context | Target knowledge | Chatbot type | Chatbot feature |
|----------|------------------|--------------|---------|-------------------------|---------------------------------------|---|
| [3] | Higher education | 144 | - | Healthy eating behavior | Embodied conversational agent (GRETA) | - Various presentation types - Facial expression - Emotional expression - Modality |

| Ref. no. | Setting | Participants | Context | Target knowledge | Chatbot type | Chatbot feature |
|----------|------------------|-------------------------|---|------------------------|--|---|
| [6] | | 108 adults | Lab experiment | | Artificial conversational agent (Cleverbot) | Modality |
| [9] | Higher education | 123 undergrads | Meta tutoring environment | Circulatory system | Four pedagogical agents - Gavin the guide - Mary the monitor - Pam the planner - Sam the strategizer | Prompt and feedback |
| [14] | Higher education | 142 college students | Computer literacy course | Instructional planning | Pedagogical agent as a learning companion (PAL) | Gender difference - Emotional expression |
| [14] | Higher education | 56 pre-service teachers | Course in introductory educational technology | Instructional planning | Pedagogical agent as a learning companion (PAL) | Gender difference - Empathic expression |
| [18] | Higher education | 60 undergrads | Common dialogue | | Embodied conversational agent (ECA) | Facial expression - Head movement |
| [21] | Secondary school | 61 third-years | Inquiry learning | Kinematics | Animated pedagogical agent (APA) | Motivational scaffolding - Modality |

The major findings of the studies are listed in table 6. Overall, the results showed a tendency for participants to project their human-to-human interaction practices to their human-to-chatbot interaction, especially when the chatbot was designed to be more human-like. In detail, participants report more positive outcomes when the chatbots express or represent emotion than when they interact with chatbots designed to exhibit neutral emotion [3, 14, 18]. They also exhibited social stereotyping towards a gendered chatbot [14]. In cases of modality, though the results were not perfectly consistent, participants seemed to better understand a text-based chatbot than a speaking chatbot [3], while they showed more human-like interaction with the latter [6, 18].

표 6. 챗봇 설계와 연관된 선행 연구 결과 요약
Table 6. Summary of results in articles

| Ref. no. | Intervention | Dependent variable | Result |
|----------|--|---|---|
| [3] | Presentation type - Neutral expression - Neutral expression (human) - Voice only - Text only - Consistent expression - Inconsistent expression | Perception - Likelihood of following - Ease of understanding - Trustworthiness - Helpful - Likeable - Quality of evidence - Convincingness Memory | Ease of understanding - Text > Neutral, human, voice Trustworthiness - Neutral, text, voice > Human Helpful - Neutral, human > Voice Likeable - Neutral, human > Voice |

| Ref. no. | Intervention | Dependent variable | Result |
|----------|--|---|---|
| | | performance | Memory performance - Voice, human, text > Neutral - Consistent > Neutral, inconsistent |
| [6] | Screen - Text - Voice Aware - Participants were informed that their interlocutor is a chatbot - Not informed | Intersubjective effort | - Voice > Text - Informed > Not informed |
| [9] | - Prompt and feedback - No prompt and no feedback | - Achievement emotions - Personality - Agent response - Pre-test - Post-test | - Relationship between trait emotions (anger, anxiety) and personality (agreeableness, conscientiousness, neuroticism) for agent-directed emotion (enjoyment, pride, boredom, neutral) - No significant relationship between personality and trait emotion on learning gain |
| [14] | Emotional expression - Positive - Negative - Neutral Gender of agent - Male - Female | - Social judgement - Interest - Self-efficacy - Learning | Social judgement - Positive, neutral > Negative - Positive male > Positive female Interest - Positive male > Positive female Learning |
| [14] | Empathetic response - Responsive - Nonresponsive Gender of agent - Male - Female | - Social judgement - Interest - Self-efficacy - Learning | Social judgement - Male > Female Interest - Responsive > Nonresponsive Self-efficacy - Responsive > Nonresponsive |
| [18] | Interaction mode - Written input - Spoken input Subject groups - Science - Humanities | User attitude | - Spoken input produces a warmer attitude and richer language use - This effect is more evident in the Humanities group |
| [21] | Time - Pre-intervention - During intervention 1 - During intervention 2 - After intervention Condition - Visible agent with voice - Voice only - No agent Student gender - Boy - Girl | - Task relevance change - Self-efficacy over time - Agent appraisal - Pre-test - Post-test | Self-efficacy - Boy > Girl - No main effect for condition Agent appraisal - Girl > Boy Learning - Condition & gender fixed, students made significant progress over time - Benefits of agent group over control group is doubtful |

4-2 Research question 2: What implications for educational chatbots can be derived from the studies?

From the review, we reorganized the findings with similar attributes and characteristics. Explanations for each attribute were

then elaborated in the learning context. The implications are as follows.

- *Live emotion* – chatbots are better when designed to display consistent facial expressions or positive emotional expressions.
- *Neutral emotion* – a chatbot with a neutral emotional expression is more acceptable for persuasion.
- *Modality* – written text is better for delivering information or a guiding process; spoken text is better for affective support.
- *Extraneous* – too many animated or visual graphics have a detrimental effect on performance.
- *Gender* – people project social gender stereotyping according to the chatbot’s gender; people value information from a chatbot differently, depending on its gender representation.
- *Bot effect* – a chatbot can perform works that are redundant and require accuracy better than a human can.
- *Imitation* – more human-like chatbots drive more human-like interactions and establish a trusting relationship when giving information.

After extracting the implications, they were matched with each role of the educational chatbot (i.e., tutor, assessment, question and answer, communication, common dialogue); see table 7.

표 7. 도출된 교육용 챗봇 설계 원리

Table 7. Implication from review for educational chatbot

| Educational role of chatbot | Implication from the studies |
|-----------------------------|--|
| Tutor | <i>Live emotion</i> – chatbots are better when designed to display consistent facial expressions or positive emotional expressions <i>Modality</i> – written text is better for delivering information or a guiding process; spoken text is better for affective support <i>Extraneous</i> – too many animated or visual graphics have a detrimental effect on performance |
| Evaluator | <i>Bot effect</i> – a chatbot can perform works that are redundant and require accuracy better than a human can |
| Responder | <i>Gender</i> – people project social gender stereotypes to the chatbot’s gender; people value information from a chatbot differently, depending on its gender representation <i>Modality; text</i> – written text is better for delivering information |
| Moderator | <i>Neutral emotion</i> – a chatbot with a neutral emotional expression is more acceptable for persuasion and establishing a trusting relationship than for giving information |
| Peer learner | <i>Modality; voice</i> – spoken input produces a warmer attitude and richer language use <i>Imitation</i> – more human-like chatbots drive more human-like interaction <i>Neutral emotion</i> – a chatbot with a neutral emotional expression is more acceptable for persuasion and establishing a trusting relationship than for giving information |

V. Discussion

This study derives design principles according to the role of a chatbot by using a systematic review of recently published literature on educational chatbots. This approach can be expected to help in the design and development of educational chat-bots in situations where there is insufficient chatbot development and related research in an educational context. The findings of this study can be summarized as follows.

5-1 Key result

In order to derive design principles for educational chatbots, the seven studies examined in this study examined how appearance characteristics such as facial expressions, gender, and style of chatbot affect the learning process and performance. As a result, when the chatbot expresses emotionally rather than neutrally, text-based rather than speech-based human interactions contribute more to learning. The design principles derived from this are the Live emotion principle, Neutral emotion principle, Modality principle, Extraneous principle, Gender principle, Bot effect principle, Imitation principle, and so on. In addition, this study matched design principles to be considered according to the role of chatbot when designing an educational chatbot. When designing a chatbot that plays the role of a tutor, it is necessary to consider the Live emotion principle, Modality principle, and Extraneous principle. When designing a chatbot that acts as an evaluator, the Bot effect principle should be considered. When developing a chatbot that acts as a responder, the Gender principle and Modality principle should be considered. In the case of a chatbot that plays the role of a moderator, it is necessary to consider the Neutral emotion principle, and in the case of a chatbot that plays the role of peer learner, the Modality principle (voice), the Imitation principle, and the Neutral emotion principle should be considered. In this study, we explored some principles for educational chatbots based on previous studies, but most of them were related to the appearance characteristics of chatbots. In the future, research is needed on the contents presentation method of chatbots and differentiated roles.

5-2 Areas for further study

As mentioned above, there are relatively few studies on the principles to be considered in the design of educational chatbots and the appropriate design principles according to the role of the chatbots. Related research needs to be actively conducted in the future, and research on suitable design principles is required according to the purpose and role of the chatbot.

Prior studies have found that it is difficult to find consensus on the characteristics of educationally effective chatbots, but learners

want to learn with more human and emotional chatbots. Although this may be beneficial in terms of motivation, further research is needed to determine whether it will have significant effects on learning outcomes. In addition, it is necessary to study the differences between education through chatbots and through other educational methods, and in short- and long-term settings.

It is also necessary to study how the role of the instructor and how the interaction between the instructor and the learner is changed by the educational use of the chatbot. Research is also required on the side effects of using chatbots and the degree of acceptance according to learners' characteristics; for example, study of how the chatbot's performance varies according to a learner's ability to use a computer, propensity to cooperate, learning style, and learning level. There is also a need for research on the cost-effectiveness of educational use. It is also necessary to discuss which educational context is the most effective when a chatbot is used for any educational purpose, and that from a cost-effectiveness analysis it is worth introducing a chatbot.

5-3 Limitation

This study has some limitations. First of all, although some papers have educational contexts, they include cases that are not for educational purposes, so it is hard to say that they derive principles entirely for educational chatbots. Since this study did not examine the gray literature, such as theses, current research, academic journals, and research reports, there is a possibility of publication bias. It is also difficult to avoid language bias because it includes papers in English only. However, this study attempted to study the special area of the educational chatbot, which was not sufficiently examined in the past, and it is considered to have sufficient advantages because it tried to derive differentiated principles. In order to develop a chatbot with various purposes and roles for educational purposes, it is necessary to make various efforts with various experts.

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