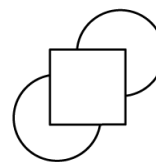


# Designing a virtual learning coach for support of digital literacy of senior learners in context of the electronic health record. Design considerations in the ePA-Coach project.

Prof. Ilona Buchem  
Carolin Gellner



BEUTH HOCHSCHULE  
FÜR TECHNIK  
BERLIN  
University of Applied Sciences



**ICERI** 2020



Federal Ministry  
of Education  
and Research

## Introduction

- **Digital literacy** and **digital sovereignty** in dealing with digital technologies and data are important conditions for the participation of **elderly people** in modern societies.
- new approaches to promoting digital literacy among senior learners with focus on the demands of specific fields such as healthcare has called
- For example in **Germany** the **electronic health record** (*German: Elektronische Patientenakte, ePA*), which enables to electronically collect, manage and share health-related data <sup>[1]</sup>
- Senior citizens have to **deal with** a large number of **different institutions** and **highly diverse health-related data** and in view of the electronic health record, the informational autonomy and digital sovereignty of senior citizens becomes crucial.

The **ePA-Coach project** addresses this challenge and **aims to develop a coaching-based e-learning system for senior learners to enhance their digital literacy against the background of the electronic health record (ePA).**

We describe the approach to **designing a virtual learning coach** (pedagogical agent) as part of the **e-learning** system for digital literacy of **senior learners.**

## BACKGROUND: Pedagogical agents

A **pedagogical agent** „[...] is an agent (single or multi) in the form of a virtual character equipped with artificial intelligence that can support the students' learning process and use various instructional strategies in an interactive learning environment“ [2]

Course of research focus [2]:



Pedagogical agents can have a **significant impact on** [2]:

- student **learning outcomes** and
- learning **motivation**

## LITERATURE REVIEW: Design of pedagogical agents

### Viewed publications for general design of pedagogical agents:

- Link et al. (2001): Influence of **speech parameters** and **facial expressions** [4]
- Baylor et al. (2003): Effects of **voice and animation** on learning, motivation, and agent persona [5]
- Gulz and Haake (2005): Learner preferences regarding the **visual and social style** [6]
- Schwind (2018): Preferences of users towards **virtual faces**[7]
- Salehi and Nia (2019): Effect of different levels of **realism** on learning [8]
- Lin et al. (2020): Effects of **social cues** on learning outcomes, cognitive load, and intrinsic motivation [9]



Quelle: <https://www.botlibre.com/graphic?id=11791105>  
CC BY 3.0

## LITERATURE REVIEW: Design of pedagogical agents

### Viewed publications for preferences of senior users:

→ *still little research into the preferences of senior citizens regarding pedagogical agents*

- Straßmann and Krämer (2017): Preference of the **appearance** [10]
- Straßmann et al. (2020): Effects of **species, realism** and **embodiment** [11]
- Esposito et al. (2019): Preference of agent **gender** and **rating** of the agent depending on affinity for technology [12]
- Feledichuk (2019): Design preferences regard for **animation, communication and voice, graphical style, agent role, competence, facial expression, gender, body shape, ethnicity, age, and attire** [13]



## LITERATURE REVIEW: Design of pedagogical agents

### Viewed publications for frameworks for designing pedagogical agents

- Baylor (2004): **Four dimensions of control** [14]
- Ryu & Baylor (2005): **Four factor model** for measuring the perception of the psychometric structure [15]
- Veletsianos et al. (2010): **EnALI** - Enhancing Agent Lerner Interactions Framework [16]

## LITERATURE REVIEW: Types of pedagogical agents

*Some publications describe different types or approaches of virtual pedagogical agents.  
For example the three following types:*

### Pedagogical agents as learning companions (PALs)

- „[...] animated **peer-like characters** that simulate peer interaction in computer-based learning.” [18]
- Opportunity to **simulate social interaction** in computer-based learning [17]
- **Social-cognitive framework for designing PALs** by Kim and Baylor (2006) [17]
- Kim et al. (2006): **Effects of competence and interaction type** [18]

### Embodied (conversational) agents (EPA and ECA)

- Haake and Gulz (2009): Effects of **visual static appearance, role & communication style** [19]
- Scholten et al. (2019): Preference of conditions: animated, speech, still, speech, still, text, and text-only [20]

### Animated pedagogical agents (APA)

- Lester et al. (1997): Impact of the **communication behaviour** [3]
- Shaw et al. (2000): Preference of the use of an **animated pedagogical or text-only-tutor** [21]

# REQUIREMENTS FOR DESIGNING PEDAGOGICAL AGENTS

## *Frameworks*

**Development and design** can be conducted in a systematic way, **based on frameworks:**

Dimensions of control by Baylor (2004) [14]

Four-factor-model by Ryu & Baylor (2005) [15]

Framework enALI by Veletsianos et al. (2010) [16]

Social-cognitive framework by Kim & Baylor (2006) [17]

Framework by Haake & Gulz (2009) [19]

**Aspects that should be considered** when designing pedagogical agents:

visual style / appearance [15,16,17,19]

communication style and interaction [16,17,19]

feedback / message [14,16,17]

competence and credibility [14,15,17]

agent-role [14,19]



# REQUIREMENTS FOR DESIGNING PEDAGOGICAL AGENTS

## *Visual appearance*

*Results of the studies described in the literature review shows the following results for preferences:*

### Realism

- realistic / human-like [7,8,10,13]
- iconic /cartoon / machine-like [6,10,11]

### Animation

- animated [3,5,21]
- no preference or positive effect [13,20]
- negative effects [5]

### 2D/3D

- most popular:3D [2]
- irrelevant [10]

### Gender

- female [7,12]
- no preference [13]

### Facial expressions

- friendly [13]
- smooth skin, realistic proportions, natural skin color [7]
- female: full lips, snob nose, slightly upturned eyes [7]
- male: strong eyebrows, downturned eyes, larger throat, thin lips [7]
- hair color: irrelevant [7]

# REQUIREMENTS FOR DESIGNING PEDAGOGICAL AGENTS

## *Communication and interaction*

### Social style

- task- & relational-oriented [6,13,19]
- relational-oriented [6]
- task-oriented [13]

### Speech style

- speech / verbal [3,20]
- easy-going demeanour [13]
- conversational style increased pressure and mental effort [9]
- perception of feedback depends on linguistic expressions and mouth curve [4]

### Voice

- real-voice [5,13,21]
- machine-generated [5]

# REQUIREMENTS FOR DESIGNING PEDAGOGICAL AGENTS

## *Competence and role*

### Competence

- high-competency <sup>[18]</sup>  
→ higher learning outcomes
- confident <sup>[13]</sup>
- low-competence <sup>[18]</sup>  
→ better self-efficacy beliefs

### Role

- used for help & feedback <sup>[3,4,5,6,11,20]</sup>
- used for giving instructions <sup>[5,8,9,15,19,20]</sup>
- experts and teachers <sup>[13]</sup>
- in most studies as information source <sup>[22]</sup>
- in a few studies for coaching & scaffolding <sup>[22]</sup>

# TECHNOLOGIES FOR DESIGNING PEDAGOGICAL AGENTS

*No details were given on the technical implementation of the agents in many publications [3,8,9,11,13,15,18,20].*

The agent was often developed using already existing tools and software, for example:

Microsoft Agent<sub>[4,5]</sub>, Natural Reader & Audacity<sub>[12]</sub>, 3D computer graphics program Poser<sub>[5]</sub>, Macromedia Director & 3D Studio Max 5 (with plug-in module FacialStudio)<sub>[6,19]</sub>, BOTLIBRE<sub>[12]</sub>, etc.

- **limited information** about the technical tools and the implementation of agents
- **Only a few** of the tools used in previous studies are **freely available**
- **Some tools** such as the Microsoft Agent tool, are **out of date** and no longer available <sub>[23]</sub>

## DESIGN OPTIONS AND CONSIDERATIONS FOR EPA-COACH PROJECT: VISUAL STYLE

Based on the results of the literature review, we defined **design options for four virtual agents** (Lisa, Maria, Max, and Peter) **to be tested** in the ePA-Coach project with the group of senior learners:

	<i>Lisa (1)</i>	<i>Maria (2)</i>	<i>Max (3)</i>	<i>Peter (4)</i>
Gender	female	female	male	male
Animation	yes	no	yes	no
Age	35	60	35	60
Form	3D	2D	3D	2D
Realism	human-like	human-like	human-like	human-like
Facial expressions	mouth: smiling (default), neutral, sad, open, closed	mouth: slightly smiling (fixed)	mouth: slightly smiling (fixed)	mouth: smiling (default), neutral, sad, open, closed
Face style	smooth skin, realistic proportions, natural skin color, full lips, snub nose, slightly upturned eyes		smooth skin, realistic proportions, natural skin color, strong eyebrows, downturned eyes, larger throat, and thin lips	

## DESIGN OPTIONS AND CONSIDERATIONS FOR EPA-COACH PROJECT: COMMUNICATION & SOCIAL STYLE

	<i>Lisa (1)</i>	<i>Maria (2)</i>	<i>Max (3)</i>	<i>Peter (4)</i>
<b>Social style</b>	relational-oriented	task- & relational-oriented	task- & relational-oriented	task-oriented
<b>Speech style</b>	speech	text	speech	text
<b>Voice</b>	human	-	machine	-

In addition, we will follow the **guidelines** of the **EnALI-Framework** by Veletsianos et al.<sup>[16]</sup>

## DESIGN OPTIONS AND CONSIDERATIONS FOR EPA-COACH PROJECT: *PEDAGOGICAL ROLE & COMPETENCE*

	<i>Lisa (1)</i>	<i>Maria (2)</i>	<i>Max (3)</i>	<i>Peter (4)</i>
<b>Role</b>	pedagogic-expert	eLearning-expert	ePA-expert	health-expert
<b>Job / qualification</b>	geriatric educator	professor for educational technology	Gematik GmbH employee	doctor for geriatrics
<b>Competence</b> <i>pedagogic</i> <i>geriatrics</i> <i>ePA</i> <i>technology</i>	high middle low low	middle low low high	low low high high	low high middle low

## CONCLUSIONS

The **current literature of designing pedagogical agents** was described and **design options** for a pedagogical agent as a **virtual learning coach** as part of the e-learning system for digital literacy of senior learners in the project ePA-Coach were **derived**.

### Literature review

- **Studies and frameworks** for the **design of pedagogical agents**.
- Different **types of agents** (PAL, EPA, ECA and APA)

### Requirements for designing pedagogical agents

#### Main aspects of existing frameworks and state of research

- **Preferences** are **not consistent** or even contradictory
- Past studies could identify **only slight tendencies** with **small samples**
- **Preferences** for **human-like** designed agents, especially among seniors, or a slight preference for **high competence** agents and **female** agents



## CONCLUSIONS

### Used technologies

**Technologies were used** for designing pedagogical agents  
→ many studies give **no details** on the technical implementation

### Considerations for the ePA-Coach project

Description of considerations for the ePA-Coach project and the **design options for four different agents** including the **visual style**, the **communication and social style**, and the **pedagogical role**.

## NEXT STEPS IN ePA-COACH PROJECT

- Design and testing of the mock-ups of the four agents
- Identify **preferred options** for designing a final learning coach version in the ePA-Coach project
- Examine the possibilities for the implementation of the **agent intelligence and behaviour**
- Design and implement at least one **prototype**

## FURTHER RESEARCH

- In general: **studies for designing agents**  
→ actual no generalisable findings
- Studies on agent **preferences of senior users**  
→ lack of research; research showed differences among different target groups
- Give detailed **information on the technical tools and the implementation**  
→ most studies only show effects and preferences
- Virtual agents in **different roles**, for example **(learning) mentor or coach**  
→ most studies only use agents as instructors and sources of information

## REFERENCES

- [1] A. Pott, "EHR and PHR : digital records in the German healthcare system," *Healthcare industry*, 2019. <https://www.gesundheitsindustrie-bw.de/en/article/news/ehr-and-phr-digital-records-in-the-german-healthcare-system> (accessed Aug. 13, 2020).
- [2] A. S. D. Martha and H. B. Santoso, "The design and impact of the pedagogical agent: A systematic literature review," *J. Educ. Online*, vol. 16, no. 1, 2019, doi: 10.9743/jeo.2019.16.1.8.
- [3] J. C. Lester, S. T. Barlow, S. A. Converse, B. A. Stone, S. E. Kahler, and R. S. Bhogal, "Persona effect: Affective impact of animated pedagogical agents," *Conf. Hum. Factors Comput. Syst. - Proc.*, pp. 359–366, 1997.
- [4] K. E. Link, R. J. Kreuz, and A. C. Graesser, "Factors that influence the perception of feedback delivered by a pedagogical agent," *Int. J. Speech Technol.*, vol. 4, no. 2, pp. 145–153, 2001, doi: 10.1023/A:1017383528041.
- [5] A. L. Baylor, J. Ryu, and E. Shen, "The effects of pedagogical agent voice and animation on learning, motivation and perceived persona," *ED-MEDIA 2003 Proc. World Conf. Educ. Multimedia, Hypermedia Telecommun.*, pp. 452–458, 2003.
- [6] A. Gulz and M. Haake, "Social and Visual Style in Virtual Pedagogical Agents," *Proc. Work. Adapt. Interact. Style to Affect. Factors, 10th Int. Conf. User Model.*, 2005.
- [7] V. Schwind, "Implications of the Uncanny Valley of Avatars and Virtual Characters for Human-Computer Interaction," Universität Stuttgart, 2018.
- [8] V. Salehi and F. T. Nia, "Effect of levels of realism in mobile-based pedagogical agents on health e-learning," *Futur. Med. Educ. J.*, vol. 9, no. 2, pp. 40–45, 2019, doi: 10.22038/fmej.2019.39824.1261.
- [9] L. Lin, P. Ginns, T. Wang, and P. Zhang, "Using a pedagogical agent to deliver conversational style instruction: What benefits can you obtain?," *Comput. Educ.*, vol. 143, 2020, doi: 10.1016/j.compedu.2019.103658.
- [10] C. Straßmann and N. C. Krämer, "A categorization of virtual agent appearances and a qualitative study on age-related user preferences Categorization of appearance variables," in *Intelligent Virtual Agents. IVA 2017. Lecture Notes in Computer Science*, 10498th ed., J. Beskow, C. Peters, G. Castellano, C. O'Sullivan, I. Leite, and S. Kopp, Eds. Springer, Cham, 2017, pp. 413–422.
- [11] C. Straßmann, N. C. Krämer, H. Buschmeier, and S. Kopp, "Age-Related Differences in the Evaluation of a Virtual Health Agent 's Appearance and Embodiment in a Health-Related Interaction : Experimental Lab Study Corresponding Author :," *J. Med. INTERNET Res.*, vol. 22, no. 4, pp. 1–15, 2020, doi: 10.2196/13726.
- [12] A. Esposito *et al.*, "Seniors' acceptance of virtual humanoid agents," in *Ambient Assisted Living, Lecture Notes in Electrical Engineering*, 544th ed., vol. 544, A. Leone, C. A., G. Rescio, D. G., and P. Siciliano, Eds. Springer Nature Switzerland AG 2019, 2019, pp. 429–443.
- [13] D. G. Feledichuk, "The preferred design of pedagogical agents by older adults for self-management health programs for chronic conditions," University of Alberta, 2019.
- [14] A. L. Baylor, "Permutations of Control: Cognitive Considerations for Agent-Based Learning Environments.," *J. Interact. Learn. Res.*, vol. 15, no. 4, pp. 403–425, 2004.
- [15] J. Ryu and A. L. Baylor, "The Psychometric Structure of Pedagogical Agent Persona," *Technol. Instr. Cogn. Learn.*, vol. 2, no. 4, pp. 291–315, 2005.
- [16] G. Veletsianos, C. Miller, and A. Doering, "EnALI: A Research and Design Framework for Virtual Characters and Pedagogical Agents," *J. Educ. Comput. Res.*, vol. 41, no. 2, pp. 171–194, 2010.
- [17] Y. Kim and A. L. Baylor, "A social-cognitive framework for pedagogical agents as learning companions," *Educ. Technol. Res. Dev.*, vol. 54, no. 6, pp. 569–596, 2006, doi: 10.1007/s11423-006-0637-3.
- [18] Y. Kim, A. Baylor, and P. Group, "Pedagogical Agents as Learning Companions : The Role of Agent Competency and Type of Interaction," *ITLS Fac. Publ.*, 2006, doi: 10.1007/s11423-006-8805-z.
- [19] M. Haake and A. Gulz, "A Look at the Roles of Look & Roles in Embodied Pedagogical Agents – A User Preference Perspective," *Artif. Intell. Educ.*, vol. 19, pp. 39–71, 2009.
- [20] M. R. Scholten, S. M. Kelders, and J. E. W. . C. Van Gemert-Pijnen, "An Empirical Study of a Pedagogical Agent as an Adjunct to an eHealth Self-Management Intervention : What Modalities Does It Need to Successfully Support and Motivate Users ?," *Front. Psychol.*, vol. 10, no. 1063, 2019, doi: 10.3389/fpsyg.2019.01063.
- [21] E. Shaw, R. Ganeshan, W. L. Johnson, and D. Millar, "Building a case for agent-assisted learning as a catalyst for curriculum reform in medical education," *Med. Educ. AI-ED' 99 Work. Animat. Pers. Pedagog. Agents, Le Mans*, pp. 509–516, 2000.
- [22] N. L. Schroeder and C. M. Gotch, "Persisting Issues in Pedagogical Agent," *J. Educ. Comput. Res.*, vol. 53, no. 2, pp. 183–204, 2015, doi: 10.1177/0735633115597625.
- [23] Microsoft, "Microsoft Agent," 2018. <https://docs.microsoft.com/en-us/windows/win32/lwef/microsoft-agent> (accessed Sep. 22, 2020).

## FURTHER INFORMATION & CONTACT

This presentation and the associated publication were produced as part of the project *ePA-Coach: Digital sovereignty in context of the electronic patient file*, founded by the Federal Ministry of Education and Research under the program Human-technology interaction for digital sovereignty. For more information please visit: <https://technik-zum-menschen-bringen.de/projekte/epa-coach>

Prof. Ilona Buchem, PhD (Professor for Communication and Media)  
[buchem@beuth-hochschule.de](mailto:buchem@beuth-hochschule.de)

Carolin Gellner (M.Sc. Media Informatics, Research Associate)  
[cgellner@beuth-hochschule.de](mailto:cgellner@beuth-hochschule.de)