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# Scaffolding of motivation in learning using a social robot

Andrea Deublein[a], Anne Pfeifer[a], Katinka Merbach[a], Katharina Bruckner[a], Christoph Mengelkamp[b], Birgit Lugrin[c,*]

[a] University of Wuerzburg, Germany
[b] Medienkommunikation, University of Wuerzburg, Germany
[c] Human-Computer Interaction, University of Wuerzburg, Germany

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## 1. Introduction

In the societal change from an industrialized society towards a knowledge society, lifelong learning is gaining importance constantly (Gara, 2001). Knowledge as a factor of production as well as a factor of location influences the ability to compete internationally, which is essential in times of globalization (Mandl & Krause, 2001). Lifelong learning is only successful if learners are equipped with effective strategies and tools. Hence it is inevitable to explore how to optimize the learning processes and support learners in the best possible way. One key factor in this context is the motivation of learners (Roesler, 2011). Motivation can be defined as the orientation of thoughts and actions towards a positive goal (Rheinberg, 2004, p. 15). In the context of learning, motivation describes the intention to acquire skills or knowledge about a knowledge domain (Deimann, 2002), and motivation is a critical success factor as it helps to master difficult tasks and work with greater persistency (Zimmerman, 2011). The use of multimedia environments to support lifelong learning bears great potential, but is also demanding for the learners. Amongst other things, learners have to motivate themselves to start learning and not to quit the learning process. The novelty of the situation and the curiosity piqued by the technical learning support are not sufficient to keep learners motivated for extended periods of time (Keller & Suzuki, 2004). The importance of considering motivational factors while designing multimedia learning environments has already been demonstrated (e.g. ARCS model, Keller & Kopp, 1987, pp. 289–320). Especially when learners learn by themselves, without the support of a teacher or a peer, effective learning strategies help to maintain the level of motivation and thereby increase the learning outcome.

Social robots have attracted increasing attention in the last decade. They are supposed to support humans in areas such as education, therapy or care of the elderly (e.g. Tapus, Mataric, Scassellati, 2007; Scassellati, Admoni,Mataric, 2012; Mubin, Stevens, Shahid, Mahmud, & Dong, 2013). In the domain of teaching and learning, social robots can be employed to assist learners during the learning process.

To explore the potential of a social robot to increase the motivation of a learner, this study combines findings from educational psychology (the ARCS model, Keller & Kopp, 1987, pp. 289–320) with the potential of a social robot to assist learners. Therefore, a learning environment was developed in which learners are supported by a social robot in learning a language. To the best of our

* Corresponding author.
*E-mail address:* birgit.lugrin@uni-wuerzburg.de (B. Lugrin).

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knowledge, the potential of the ARCS model has not been explored using a social robot so far. The model provides strategies to promote the motivation of learners in a systematic way and has been used in various technology-based learning environments (e.g. Cook, Beckman, Thomas, & Thompson, 2009; Kim & Keller, 2008; Su & Cheng, 2015). We therefore used it as a basis for modelling the behaviour of the robot. The aim of this contribution is to investigate whether a social robot that exhibits motivational behaviour according to the ARCS model has an effect on the motivation of learners and, as a consequence, on the learning outcome.

## 2. Related work and theoretical background

### 2.1. Social robots in the context of learning

A robot is defined as a social robot if it interacts with humans, taking into account social norms and emotions (Breazeal, 2003). One of their major fields of application is in the domain of education. Here, they are predominantly used for language learning (e.g. Moriguchi, Kanda, Ishiguro, Shimada, & Itakura, 2011; Saerbeck, Schut, Bartneck, & Janse, 2010; Tanaka & Matsuzoe, 2012) or the acquisition of technical and mathematical knowledge (e.g. Kennedy, Baxter, & Belpaeme, 2015; Leyzberg, Spaulding, Toneva, & Scassellati, 2012).

Social robots appear to have an advantage compared to more traditional devices used in technology-based learning. Leyzberg et al. (2012), for example, have shown that a greater learning outcome can be achieved if a learning content is taught by a social robot, compared to on-screen display. In comparison to a human teacher, it has been shown that feelings of shame and anxiety can be reduced when using a social robot (Yang & Chen, 2007).

A major advantage of social robots is their ability to interact with humans in a natural and social manner. The way the robot presents social behaviour usually varies with the role of the robot, the learning material, and the age of the learner (Mubin et al., 2013). Previous research revealed evidence that the efficiency of the learning process can be increased by a social robot that behaves in a supportive way. Saerbeck et al. (2010) showed that learning a language with a social robot that acts in a socially supportive manner leads to an increased learning outcome compared to a social robot that acts in a neutral way. In addition, the authors showed that in a language learning scenario a social robot interacting in the role of a tutor was preferred. Further, Ushida (2010) documented that a robot exhibiting social behaviour can positively influence the retention of English vocabulary. Moreover, the author showed that the assistance of a social robot can also increase interest in the subject. Stressing the importance of the motivation of the learner, Kanda and Ishiguro (2005) found that the motivation of children who learned with robots increased significantly during the learning process. However, this effect was only maintained for a short period of time. Likewise, Chang, Lee, Chao, Wang, and Chen (2010) increased the motivation of primary school children by creating an interactive and hands-on learning experience with a social robot.

The majority of studies that successfully test teaching with social robots therefore focus on educating children, or children with special needs (e.g. Robins, Dautenhahn, Te Boekhorst, & Billard, 2005). However, there is a growing interest in teaching adult learners using social robots. Examples include research by Kidd and Breazeal (2008) or Schodde, Bergmann, and Kopp (2017), whose results suggest positive effects from using social robots in adult learning.

In this study, we use a social robot to increase the motivation and thereby the learning outcome of learners. We therefore integrate the ARCS model in the robot's behaviour in a systematic manner.

### 2.2. ARCS model

The ARCS model (Keller & Kopp, 1987, pp. 289–320) was developed from the Motivational Design Theory of Keller (1983). It provides a taxonomy of strategies that can be used to improve the motivation to learn. The ARCS model offers a set of categories and subcategories from which strategies can be selected. All the strategies are based on different concepts and theories in motivation (Song & Keller, 2001). “ARCS” is an acronym based on four motivational dimensions:

- Attention: attention and interest of the learner should be activated and maintained. Factors such as curiosity and surprising stimuli play an important role. The subcategories are: perceptual arousal (how to capture the learner's interest), inquiry arousal (how to stimulate curiosity and an attitude to ask questions) and variability (how to maintain the learner's attention by offering different methods) (Keller, 1983; Small, 1999; Visser & Keller, 1990).
- Relevance: learning goals should be relevant to the learner. A precisely defined learning goal is therefore of great importance. A link between the needs of the learners and the teaching content should be established. The subcategories are: goal orientation (how to meet learners' needs and present the objectives and usefulness of the content for the learner), motive matching (matching objectives to the student's individual needs and motives) and familiarity (how to tie instructions to learners' experiences) (Keller, 1983; Small, 1999; Visser & Keller, 1990).
- Confidence: learners should expect a positive learning outcome and attribute their success to their own abilities. They also should experience a feeling of control and competence. The subcategories are: clarify learning requirements (how to support the structure of a positive expectation of success), create opportunities for success (support and promote the perception of one's own competence) and control option (how to help learners to use their efforts and abilities as a cause of success) (Keller, 1983; Small, 1999; Visser & Keller, 1990).
- Satisfaction: learning should trigger positive emotions. Thus it is important to provide feedback to the learner and offer the possibility of assessing their own performance. The subcategories are: natural consequences (provide the learner with meaningful opportunities to apply the newly-acquired knowledge), positive outcome (how to maintain the desired behaviour of learners) and