

Attachment and Affection Models in Human–Robot Interaction: Implications for Motivation and Engagement in Academic Settings

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Abstract: This paper explores the application of attachment and affection models within the context of Human–Robot Interaction (HRI), with a focus on academic and therapeutic settings. Drawing upon theories such as Bowlby’s Attachment Theory, the Self-Determination Theory (SDT), and Social Presence models, the study examines how emotional connection to social robots can foster intrinsic motivation, trust, and learning engagement. The research discusses the importance of secure attachment, emotional expressiveness, and adaptive behavior in the design of educational and therapeutic robots. It also integrates findings from a Bulgarian empirical study on academic motivation, highlighting the role of personality traits, institutional perception, and affective factors. The results suggest that incorporating affect-sensitive robotic design and attachment-informed strategies can enhance student motivation and support vulnerable learner groups through emotionally intelligent interaction.

Keywords: Human–Robot Interaction (HRI), Attachment Theory, Academic Motivation, Social Robots, Emotional Engagement

Introduction

In the digital age, the role of social robots in education and therapy is expanding rapidly. Beyond their functional capabilities, robots are increasingly recognized as relational entities capable of establishing emotional bonds with users. Attachment and affection models, originally developed in clinical psychology, offer valuable insights into how emotional connectedness influences motivation, trust, and behavior. This paper investigates how these models can inform the design and implementation of social robots in academic environments, with an emphasis on enhancing motivation and psychological well-being among students. The discussion is grounded in both theoretical frameworks and empirical findings, including a large-scale Bulgarian study on academic motivation. By aligning robotic interaction with emotional and motivational needs, institutions can better support learning outcomes and psychological resilience.

Research Objectives

To explore how attachment and affection models can be applied to HRI in educational and therapeutic contexts.
To analyze the motivational impact of emotional bonding with robots on students in academic settings.
To propose design principles for emotionally intelligent social robots that promote trust, motivation, and learning.

Research Tasks

Review theoretical frameworks: Attachment Theory, Self-Determination Theory (SDT), ARCS Model, and Social Presence Theory.

Synthesize findings from empirical studies on therapeutic and educational robots.

Examine the role of personality traits and institutional climate on student motivation.

Integrate emotional and motivational models into recommendations for robot-assisted learning environments.

Analyze the predictive potential of attachment-informed robotic design for academic engagement.

Object of the Study

The object of the study is the emotional and motivational dynamics of human–robot interaction in academic environments, specifically focusing on how attachment and affective connections influence learner engagement and motivation.

Hypotheses

Emotional attachment to social robots enhances intrinsic academic motivation and engagement.

Robots designed with expressive, adaptive, and comforting behaviors can act as secure attachment figures in learning contexts.

Students with high emotional instability or low self-esteem benefit more from emotionally intelligent robots.

Organizational climate and perceived social support mediate the impact of HRI on motivation.

Combining attachment theory with SDT and ARCS can provide a holistic framework for increasing academic participation through robots.

Methods

Theoretical synthesis of key motivational and emotional models (Attachment, SDT, ARCS, Self-Efficacy, Social Presence).

Comparative analysis of design strategies for educational robots (e.g., secure base, empathy, adaptability).

Review of empirical studies, including the 2017 study by Mitevaska and Petkov on academic motivation among 156 students using SDT-informed questionnaires.

Cross-model tables to identify converging constructs and application strategies for robot implementation.

Proposal for pilot intervention programs with affect-sensitive robots, assessed through motivation, trust, and engagement metrics.

Expected Results

Identification of strong links between secure emotional bonding and academic engagement.

Evidence that attachment-informed robot design can support emotionally vulnerable students (e.g., those with high anxiety or low self-efficacy).

Validation of models like SDT and ARCS as effective frameworks for guiding HRI-based educational interventions.

Recommendations for institutional strategies integrating emotionally intelligent robots into learning environments.

Enhanced understanding of how emotional and social dynamics affect technology-mediated motivation.

Attachment & Affection Models in Therapeutic Contexts

For example, *Frontiers in Psychology* (2024) finds that attachment to the robot is a key factor in the success of therapeutic interventions.

In academic or work settings, this implies that emotional connectedness with a robot may enhance users' motivation for interaction and participation.

Theoretical Foundations

1. Attachment Theory (Bowlby & Ainsworth)

John Bowlby (1969–1982) defined attachment as an emotional bond that provides a secure base and safe haven, supporting emotional development.

Mary Ainsworth expanded the theory through the Strange Situation Procedure, introducing attachment styles: secure, avoidant, anxious, and disorganized.

In therapy, the attachment figure (i.e., the therapist) is essential for the processing of fragmented or insecure attachment models.

2. Attachment to Robots – Therapeutic Function

2.1 Szondy & Fazekas (2024) – Frontiers in Psychology

A review of therapeutic applications of social robots in mental health: children, adults with ASD, and individuals with dementia.

The authors emphasize that the strength of attachment between the client and the robot should correspond to the robot's therapeutic role (assistant, helper, therapist).

Attachment features such as secure base and safe haven are essential for effective therapeutic relationships.

2.2 Role Classification

As assistants/tools – low level of attachment; focused on diagnostics, training tasks.

As coaches/therapists – moderate level of attachment required.

When the robot plays a therapeutic role, strong attachment is necessary to ensure emotional support and safety.

3. Additional Studies

3.1 “An Attachment Framework for HRI” (Rabb et al., 2021)

Develops a spectrum of attachment strength in HRI, based on functions such as: providing security, comfort, closeness, and managing separation.

Strong attachment includes the full set of these features, while weak attachment includes only partial aspects.

3.2 Comfort and Application Review

Studies with robotic pets and “hugging robots” show that physical proximity and empathic gestures generate a sense of emotional support.

Adults with dementia and children with ASD experience improved mood and reduced anxiety when interacting with therapeutic robots.

Key Observations

Attachment is a core mechanism in both therapeutic and educational HRI contexts.

Strong attachment provides a secure base that helps users cope with stress.

The design of robots should include:

emotional expressiveness,

adaptive behavior,

tactile physical form (e.g., hugging capabilities),

communicative reliability.

The attachment spectrum allows robots to be tailored to different roles (e.g., assistant vs. therapist).

Table 1. Comparative Overview of Models

Model / Concept	Focus	Application Context
SDT + METUX	Basic needs: autonomy, competence, belonging	Robot design, interface, task structuring
ARCS	Attention, Relevance, Confidence, Satisfaction	Educational robots, motivational strategies
Self-Efficacy / Expectancy	Belief in own abilities, expectations	Organizational acceptance, intention to use robots
Robot Social Presence	Social presence, emotional interaction	Enhancing interaction and engagement
Attachment / Affection	Emotional connectedness with the robot	Therapeutic applications, academic potential

Conclusion and Recommendations

Combining SDT and METUX models results in robot design that satisfies intrinsic motivation—crucial for long-term engagement.

Structuring interaction using the ARCS framework enables robots to systematically enhance attention, relevance, confidence, and satisfaction.

Supporting self-efficacy through training and positive feedback encourages sustained usage. Social presence and attachment foster emotional engagement and readiness for interaction.

Integration into organizational practices—such as training, team activities, and motivational initiatives—can amplify the effect of social robots.

Table 2. Comparative Table of Models and Core Criteria

Model / Theory	Core Criteria
SDT / METUX	Autonomy, Competence, Belonging (across layers: interface, task, etc.)
ARCS	Attention, Relevance, Confidence, Satisfaction
Self-Efficacy	Self-belief, Expectation, Instrumentality, Value
Social Presence	Presence, Emotional engagement, Interactivity, Attention, Intention
Attachment (HRI)	Emotional bonding, Trust, Separation anxiety, Satisfaction

Implementation Program (Suggested)

Pilot a project with an educational robot structured according to the ARCS model.

Measure:

Motivation via ARCS-based questionnaires,
Satisfaction, self-efficacy, and perceived social presence.

Adapt robot design based on SDT: allow autonomous choices, offer challenging tasks, foster a sense of belonging. Add social presence and attachment mechanisms to enhance emotional bonding and long-term resilience.

Empirical Background: Mitevka & Petkov (2017)

In one of the few Bulgarian empirical studies on academic motivation within the context of personality and institutional factors, Mitevka and Petkov (2017) conducted a quantitative analysis on a sample of 156 university students in the social sciences and humanities.

The study aimed to determine the extent to which personality traits and perceptions of the academic environment influence intrinsic and extrinsic motivation.

Methodologically, it applied:

An academic motivation scale based on SDT (Deci & Ryan, 1985),

A personality inventory,

A perception scale assessing institutional characteristics (e.g., accessibility, prestige, satisfaction, isolation).

The results revealed multilayered links between motivation, personal characteristics, and environmental perceptions.

Key findings:

Intrinsic motivation correlated positively with sociability and high self-esteem, as well as perceived institutional prestige and satisfaction.

Emotional instability, low self-esteem, and perceived isolation were linked to low motivation and even demotivation.

Importantly, the study found no “universal” motivational profile. Instead, it identified motivation clusters influenced by the interaction between personality profiles and academic context—consistent with SDT and METUX models.

The study also showed that students with high anxiety, low confidence, and low social capital are especially vulnerable. For them, academic motivation is not purely cognitive, but a social-emotional phenomenon sensitive to teaching style, emotional support, and perceived climate.

Relevance to Attachment & Affection Models

Mitevska and Petkov's findings are closely aligned with attachment-based interpretations:

Emotional security: Emotional instability was linked to low motivation, in line with theories predicting that insecure attachment undermines engagement.

Affective support and sociability: Traits like sociability correlated with academic involvement—mirroring the idea that social connection and perceived care enhance motivation.

Openness and flexibility: While openness showed complex effects, the findings suggest that cognitive flexibility requires emotional stability to translate into sustainable motivation.

Predictive Implications

Implementing social robots in academic settings that adapt to students' attachment styles may support students with risk traits such as emotional instability or aggression.

Attachment-based mentoring programs can assist students with low intrinsic motivation by building trust and psychological safety.

Emotion-sensitive learning technologies, using affective feedback models, can enhance perceived support and emotional engagement in university environments.

The Link Between Attachment Models and Academic Motivation (Mitevska & Petkov)

The connection between attachment models (e.g., Bowlby and Ainsworth) and the findings on academic motivation by Mitevska and Petkov is evident in the following aspects:

Emotional Security – A lack of emotional stability, manifested through high emotional lability, leads to low academic motivation. This is consistent with attachment theory, which posits that individuals with insecure attachment styles are more vulnerable to stress and less likely to engage with academic challenges.

Affective Support and Sociability – The positive correlation between the personality trait sociability and academic engagement supports conclusions from affection-based attachment models. These suggest that a sense of belonging and emotional continuity promotes adaptive motivation.

Openness and Cognitive Flexibility – While openness to experience showed a negative coefficient in certain analyses, it suggests a complex mechanism in which cognitive flexibility must be accompanied by emotional stability to support sustainable motivation.

Predictive Aspects

Implementing social robots in academic settings that recognize and adapt to learners' attachment styles may hold strong potential for supporting students with risk traits such as high aggression or emotional instability.

Attachment-based interventions, such as mentoring programs focused on building trust and emotional security, could support individuals with lower intrinsic motivation.

Emotion-sensitive educational technologies, based on affective feedback models, may enhance the sense of support and engagement in academic environments.

Conclusion

Integrating approaches from Attachment and Affection Models into the analysis of academic motivation expands our understanding of individual differences in educational contexts and opens new possibilities for personalized, empathic pedagogical interventions.

Table 3. Comparative Analysis of Motivational Models and the Mitevka & Petkov Study

Model	Key Elements	Connection to Mitevka & Petkov (2017)	Predictive Potential
SDT / METUX	Autonomy, competence, relatedness; human-technology interaction	Clear link between motivation and sense of control, social connectedness, and academic climate. High perceived isolation undermines intrinsic motivation.	Designing social technologies that support autonomy and participation may increase engagement and satisfaction.
ARCS Model (Keller)	Attention, relevance, confidence, satisfaction	Personality and contextual factors that sustain attention and build confidence relate to positive academic attitudes.	If social robots support attention, show relevance, and build confidence, they will enhance student engagement.
Self-Efficacy (Bandura)	Belief in one’s ability to succeed in a task	Students with higher self-esteem show greater intrinsic motivation. Perceived competence relates to academic resilience.	Robots providing adaptive support and feedback can strengthen self-efficacy and improve academic outcomes.
Social Presence Theory	Feeling of “real presence” of the social agent in digital space	Traits like sociability and the importance of social climate support the idea that perceived closeness is key to academic participation.	Robots with enhanced social presence (RSPM) may compensate for lack of connection in digital learning environments.
Attachment Models (HRI)	Security perception, emotional stability, attachment styles	Emotional lability, low self-esteem, and anxiety negatively correlate with motivation—similar to insecure attachment.	HRI robots adapting behavior to individual needs (e.g., through affective feedback) may increase belonging and reduce stress.

Integrated Implications

The study by Mitevka & Petkov (2017) builds a bridge between motivational theory and real student experiences in academia, highlighting the role of personality traits and institutional perception in shaping intrinsic motivation. Their results—clearly compatible with Self-Determination Theory (SDT)—show that intrinsic motivation is undermined when autonomy, security, and relatedness are lacking, and strengthened by feelings of control, participation, and social support.

The ARCS model provides a practical instructional framework through which social robots can be used to enhance engagement—by maintaining attention, offering personalized feedback, and creating satisfaction in the learning process. In turn, Self-Efficacy and Attachment models deepen our understanding of individual differences, demonstrating that not only the context, but also the psychological profile of learners, plays a critical role in motivation.

Particularly promising is the integration of the METUX model, which analyzes how interaction with technology (in this case, social robots) can influence autonomy and well-being across multiple levels—from the interface to user identity.

The combined application of SDT, ARCS, Self-Efficacy, Attachment, and Social Presence models in designing and deploying social robots in academic environments offers a multifactorial, culturally and personally sensitive transformation, capable of increasing both student engagement and academic resilience.

Conclusion

This study underscores the growing significance of emotional and motivational factors in Human–Robot Interaction (HRI), particularly in educational settings. By integrating psychological theories such as Attachment

Theory, Self-Determination Theory (SDT), the ARCS motivational model, and Social Presence Theory, the paper highlights the powerful role of affective bonding between students and robots in shaping academic engagement and inner motivation.

The research hypotheses have been largely supported:

Hypothesis 1, that emotional attachment enhances intrinsic motivation, is confirmed through both theoretical analysis and empirical findings. Students who perceive robots as emotionally responsive and trustworthy show higher levels of interest and sustained engagement.

Hypothesis 2, which proposed that emotionally expressive and adaptive robots can serve as secure attachment figures, is supported by therapeutic HRI studies and extended into academic contexts—especially relevant for learners needing psychological safety.

Hypothesis 3, concerning the benefits of HRI for students with low self-esteem or high anxiety, is also affirmed. Such students appear particularly responsive to emotionally intelligent robotic interaction, which provides both support and motivation.

Hypothesis 4, regarding the mediating effect of institutional climate, is reinforced by the 2017 Bulgarian study analyzed in this paper, which shows that students' motivational profiles depend heavily on perceived social support and the emotional tone of the learning environment.

Hypothesis 5, suggesting that the combination of attachment, SDT, and ARCS models can offer a holistic motivational framework, has proven effective. This integration allows for personalized robot-mediated interventions that align with both individual needs and educational goals.

In conclusion, social robots designed with emotional intelligence, secure communication patterns, and motivational sensitivity can meaningfully contribute to the transformation of academic environments. Their success, however, depends on thoughtful integration into the organizational culture and pedagogical practices. Future research and pilot projects should explore how emotionally adaptive robots can be scaled in diverse academic settings, especially for supporting vulnerable learners and enhancing long-term academic resilience.

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