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**Multimodal interactive e-learning: An empirical study. An experimental study that investigates the effect of multimodal metaphors on the usability of e-learning interfaces and the production of empirically derived guidelines for the use of these metaphors in the software engineering process.**

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## **ABSTRACT**

This thesis investigated the use of novel combinations of multimodal metaphors in the presentation of learning information to evaluate the effect of these combinations on the usability of e-learning interfaces and on the users' learning performance. The empirical research described in this thesis comprised three experimental phases. In the first phase, an initial experiment was carried out with 30 users to explore and compare the usability and learning performance of facially animated expressive avatars with earcons and speech, and text with graphics metaphors. The second experimental phase involved an experiment conducted with 48 users to investigate their perception of avatar's facial expressions and body gestures when presented in both the absence and presence of interactive e-learning context. In addition, the experiment aimed at evaluating the role that an avatar could play as virtual lecturer in e-learning interfaces by comparing the usability and learning performance of three different modes of interaction: speaking facially expressive virtual lecturer, speaking facially expressive full-body animated virtual lecturer, and two speaking facially expressive virtual lecturers. In the third phase, a total of 24 users experimentally examined a novel approach for the use of earcons and auditory icons in e-learning interfaces to support an animated facially expressive avatar with body gestures during the presentation of the learning material. The obtained results demonstrated the usefulness of the tested metaphors to enhance e-learning usability and to enable users to attain better learning performance. These results provided a set of empirically derived innovative guidelines for the design and use of these metaphors to generate more usable e-learning interfaces. For example, when designing avatars as animated virtual lecturers in e-learning interfaces, specific facial expression and body gestures should be incorporated due to its positive influence in enhancing learners' attitude towards the learning process.

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**Keywords:** Usability, Multimodal Metaphors, E-learning, Avatar, Earcons, Speech