• CHAPTER 8 –The Need for Empirical Evaluation of Learner Model Elements

Heather K. Holden and Anne M. Sinatra

U.S. Army Research Laboratory (ARL) - Human Research and Engineering Directorate (HRED)

Zhen Wang

Central China Normal University

Overview

- **Section 1**

  The gaps exist in Learner Modeling research, and how the authors plan to address these gaps in this paper.
- **Section 2**

  A brief introduction to the Learner Model Elements.
- **Section 3**

  The empirical evidence in the field of Human-Computer Interaction (HCI) User Modeling.
- **Section 4**

  Recommendations on the development of Learner Models.
- **Section 5**

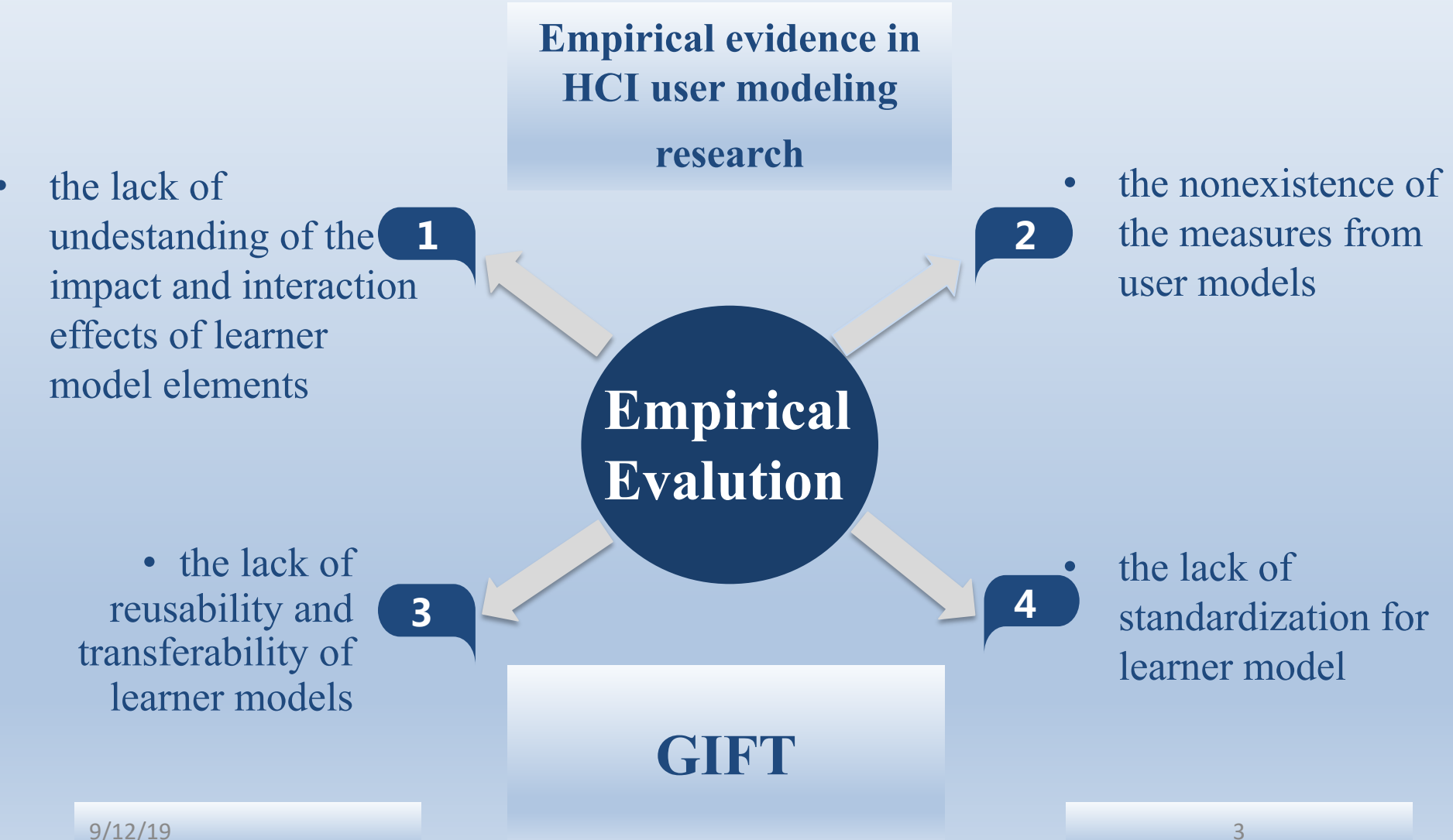
  My reflection on future empirical research.

1 The gaps exist in Learner Modeling research

- **The learner model is a vital part of an ITS.**

- **The data stored in the learner models enables ITSs to customize instruction and to adapt to the individualized needs of the learner.**

factors limiting the development of the learner models



2 Learner Model Elements

It allows the model to be more generalized across multiple populations.

Learner Model

- **domain-specific**
  - learner's state and level of knowledge or ability within a particular domain
    - historical competency,
    - misconceptions,
    - problem-solving strategies,
    - etc.

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- **domain-independent**
  - learner-specific characteristics [individual differences]
    - learning goals,
    - learning preferences,
    - demographics,
    - cognitive and affective dimensions,
    - personal control beliefs
    - etc.

The influence of and interrelationship between domain-independent information

- **Limitations:**

- **Understanding impact and interaction effects of learner model elements takes "big data," recurring empirical evaluation and experimentation.**

- **However, learner models are typically developed standalone and tightly coupled within the specific ITSs, most of which only accommodate one well-defined academic domain, resulting in the lack of standardization of learner model elements.**

- **HCI user modeling research can provide the ITS learner modeling research with a potential solution.**

3 The Human-Computer Interaction (HCI) User Modeling

- **Learner models and modeling is a subset of user models and modeling** (Self, 1988).
- **Both user and learner modeling share common tasks including**
- **(1) initializing the user or learner model;**
- **(2) drawing assumptions about the user or learner based on system interactions and updating the model accordingly;**
- **(3) supplying other system components with assumptions about the user or learner, as needed.**

- **user and learner models differ in the following ways:**

	User Models	Learner Models
Research area	a subdivision of HCI, and the goal is to build useful and usable systems.	a subdivision of AI, and the goal is to build systems that portray intelligent behavior
Model Content	include and emphasize users' system preferences, behaviors and interactions with the system	learners' cognitive and affective states, domain competency and self-efficacy, etc.
Adaptation Techniques	focus on modifying/adapting the system's interface design based on the user model.	modifying/adapting instruction based on the learner model

3.1 Empirical evidence on the impact and interation effects of individual differences in HCI research

- **user requirements:**

- **HCI research has realized that understanding users' needs is at the core of successful interactive technology design and adoption.**

- **Thus, HCI research has extended its objective to gaining a thorough understanding of the impact of user individual characteristics on interaction with the system.**

- **Important individual characteristics in HCI user model research:**

- **users' acceptance,**
- **preferences,**
- **usage behavior**
- **perceived usability and usefulness**
- **attitudes toward the system**

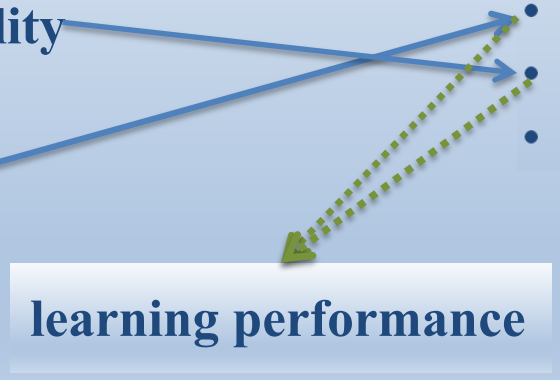
- **ITS research can leverage some of these elements to ascertain a clearer distinction between factors influencing a learner's cognitive and affective knowledge and factors that are directly linked to system interaction and usage behavior.**

The need for investigating the impact and interaction of individual characteristics, and how these elements influence their system interactions.

- **An experiment conducted to investigate the interaction among users' individual differences and learning outcomes through the use of an e-learning application**(Granic & Adams, 2011;Granic & Nakic, 2007):

- **personal user characteristics**
- **intelligence**
- **emotional stability**
- **extraversion**
- **mental stability**

- **system-dependent user characteristics**
- **experience using computers**
- **motivation to learn programming**
- **expectations from e-learning**
- **background knowledge**



- **For learners, their motivational characteristics are important factors influencing their learning behaviors, learning processes and learning outcomes** (Schultz, Alderton & Bordwell-Hyneman, 2011).
  - **Learners' intrinsic motivation, goal orientation, self-efficacy beliefs and need for achievement are directly related to an overall motivation to learn and learning performance** (Glavinic & Granic, 2008; Schultz et al., 2011).

- **These motivational characteristics should be contained within the learner model structure;**

- **However, research assessing the influence of learners' motivational characteristics on outcomes and their relationships to other individual difference variables is practically non-existent.**

- **Current learner models have a limited ability to account for individual differences as explanations of learner's cognitive and affective knowledge.**

- **Usability evaluation :**
  - **perceptions of a specific technology's usefulness and usability**
  - **Learners' "Flow" and "perceived usefulness of the e-learning system" are two vital factors influencing learning** (Liu, Liao & Peng, 2005).
  - **A recent meta-analysis found that perceived usefulness is the strongest predictor of a learner's adoption of an e-learning technology** (Sumak, Hericko & Pusnik, 2011).
- **Future research should focus on the value of usability evaluation in modeling interactions between learners and ITSs**

3.2 How to conduct usability evaluations

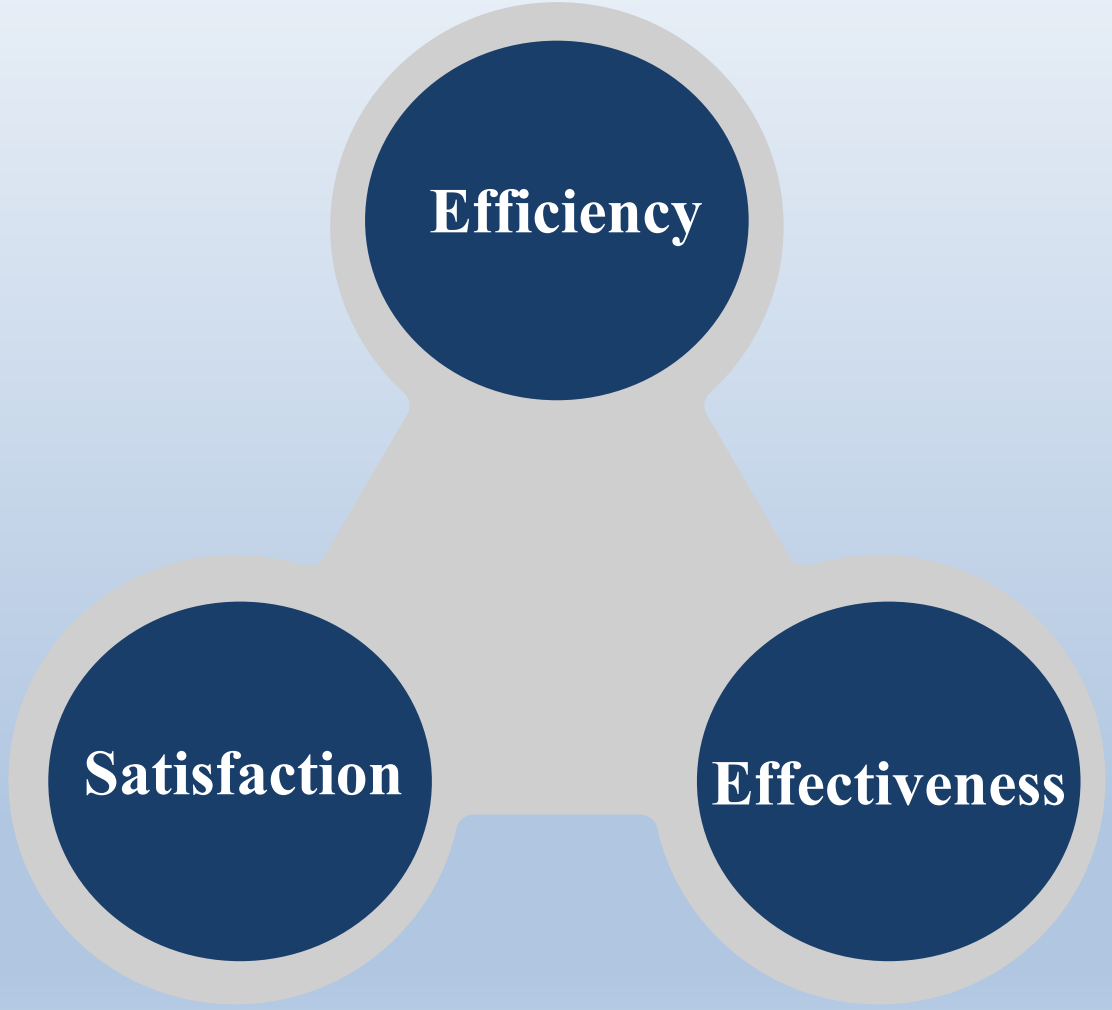
- Determine evaluation principles
- Construct specific indicators or tasks
- Determine evaluation methods
- Analyze data
- Summarize problems and provide guidlines

Nielsen, 1994

Principle	Meaning
Immediate Feedback	For any action of the user, the system should provide immediate response and feedback.
User Language	Any information given by the system shoul be easily understood by users.
Free Control	Enable users to experience a sense of control.
Consistency	The layout, function and structure of the system will not change according to different situations.
Error-proofing	Design reasonably to minimize erroneous operations
Rapid Identification	Significantly identify operating instructions to reduce the user's memory load
Flexible and Efficient	Enable users to quickly and proficiently master operations using shortcuts
Aesthetic and Concise	The design of the interface should be aesthetically pleasing and concise, so that users can quickly retrieve the required information.
Support for Correction	The system should indicate the user's error in a friendly way.
Humanized Help	Provide help file and question answering function to support users.

ISO 9241/11

- learning performance/learning time



- subjective satisfaction

- error rate
- learning performance

Evaluation methods

Method	Meaning
Heuristic evaluation	involves having usability specialists judge whether each element follows established principles
Cognitive walkthroughs	involves having usability specialists simulate a user's problem solving process at each step
Eye-traking	involves recording data such as the user's gaze point and gaze time during their interaction with the system
Questionnaire	involves collecting users' opinions through self-reports. Common questionnaires include After-Scenario Questionnaire, System Usability Scale, Post-Study System Usability Questionnaire
Think-aloud	involves requiring users to speak out their feelings during their interaction with the system

4 Recommendations on the development of Learner Models

- **4.1 Practical Implications:**

- **It is necessary to empirically evaluate the impact and interactions of specific learner model elements.**
  - **the lack of comprehensive examination of the learner model elements**
  - **researchers examined the individual difference elements within their learner models, it is within specific domains with limited generalizability (Granic, 2008b).**

- **More empirical studies should be conducted to lead to a generalizable learner model, which will contain useful information that can be applied in ITSs of varying domains.**

4 Recommendations on the development of Learner Models

- **4.1 Practical Implications:**

- **It is difficult to separate out the user's learning outcomes from their ability to understand and use the system.**
  - **layer evaluations**
  - Rather than trying to examine the entire system, individual pieces are evaluated and empirical studies are run at each part (Mulwa et al., 2011).

4 Recommendations on the development of Learner Models

- **4.2 Experimental Design Recommendations:**

- **Literature review**

  - **It can provide an overview of the different techniques that are used to assess ITSs and learner model elements.**

  - **It may also lend insight into which elements are commonly included in learner models and which ones have been found to be effective.**

4 Recommendations on the development of Learner Models

- **4.2 Experimental Design Recommendations:**

- **Meta-analysis.**

  - **The meta-analysis would show which elements of learner models were consistently helpful between domains and which ones are domain specific.**

  - **It could give researchers a direction to take when generating specific experiments to test what elements matter in what situations.**

  - **It also would give researchers a better understanding of potential interactions that exist between learner model elements.**

5 Advantages of Using GIFT as Design Recommendations

- **GIFT is a domain-independent framework, it therefore allows researchers to design their content to work with it, rather than having to develop their own delivery system.**

- **It will significantly reduce the amount of time and effort that would go into developing an ITS.**

5 Advantages of Using GIFT as Design Recommendations

- It provides a consistent structure for the development of ITSs.
- It creats favorable experimental conditions for empirical evaluation of learner model elements.
- It can improve generalization and validation of research conclusions.

6 Conclusions

- It is important for research in the ITS field to:
- (1) examine the impact and interaction effects of learner model elements;
- (2) increase the reusability and transferability of learner models into different domains;
- (3) look to fields such as HCI for guidance;
- (4) begin to move toward standardization of learner models.

7 What can we do in future research?

- **7.1 Emotional Dimension**
- **The emotional dimension may also play an equally important role when users work with systems.**
  - **Emotional design has been identified an important factor influencing learning processes and learning outcomes** (Mayer & Estrella, 2014; Plass, Heidig, Hayward, Homer, & Um, 2014; Um, Plass, Hayward, & Homer, 2012).
  - **For example, positive emotions induced in the process of interacting with the learning system may increase learning time and learning engagement.**
- **Therefore, future research needs to pay more attention to the emotional dimension of the learning system.**

7 What can we do in future research?

- **7.2 Dynamic individual characteristics**

- **Many learner characteristics are dynamically changing during the learning process, such as learning motivation, learning emotions and learning goals.**

- **How to accurately capture the dynamic changes of learner's individual characteristics to provide adaptive support is a challenge.**

7 What can we do in future research?

- **7.3 Long-term benefits of ITSs**

- **The existing empirical research in the field of HCI and ITS mostly uses cross-sectional design, which could not determine the causal relationships among the variables.**

- **Longitudinal studies should be conducted to examine the long-term effect of the systems.**