

## **EVALUATION OF PEDAGOGICAL RICHNESS AND USABILITY OF E-LEARNING SYSTEMS FOR THE DEAF AND HARD OF HEARING**

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### **Abstract**

In the field of e-learning, there is a lack of evaluation methods tailored to e-learning systems for the deaf and hard of hearing. In this paper, we present an overview of existing evaluation methods for e-learning systems for deaf and hard of hearing and propose an evaluation method for measuring pedagogical richness and usability — the PRU method. It defines factors that should be considered within three dimensions: (a) learning styles, (b) media, and (c) interaction.

### **Introduction**

Distance education (Holmberg, 2003) is denoted as a learning process where personal relations between learners and teachers, study pleasure, and empathy between students are central. Feelings of empathy are fostered by conversation-like presentations of teaching material and friendly mediated interaction between students and teachers. Communication on the Internet gives a chance for spontaneous interaction, because it serves individual learners who cannot or do not want to make use of face-to-face teaching. So, communication and empathy promote students' motivation to learn. It means that in e-material for deaf and hard of hearing, communication between teacher and deaf learners should be assured with appropriate tools in their mother tongue — sign language. However, good interaction between teacher and learners is a key for their success and efficiency. Likewise, the content of e-material should be accessible to deaf and hard of hearing users since they have low level of reading literacy (Golding-Meadow & Mayberry, 2001) and literacy skills are essential to success in today's technological society (Luckner et al., 2005/2006). Hence, the content should be provided in sign language.

When an e-learning system is designed, it is essential to evaluate its conformity with expectations and level of success. We also gain a better understanding of the

problems regarding e-learning (Graham, 2006). Evaluators often face the decision of which evaluation method to choose. They should know what the purpose of evaluation is, what they want to evaluate, what data they want to gather, and the goal of the evaluation. Moreover, it is useful when the evaluation method considers the context of the e-learning system and its target group.

This paper aims to provide an overview of existing evaluation methods for e-learning systems that are tailored to people with hearing loss, as well as to present a comprehensive model for measuring pedagogical richness and the usability of e-learning systems for the deaf and hard of hearing. It was inspired by Sonwalkar's idea of Pedagogical Effectiveness Index and is developed on the basis of our own experience with e-learning system adjusted to people with hearing loss.

## **Background and Related Work**

Currently, in the field of e-education, several approaches to evaluation of e-learning systems for deaf and hard of hearing are in use. The System Usability Scale – SUS (Bangor et al., 2008) enables measuring usability of e-learning systems and gives a view of subjective assessments of usability. It consists of ten statements using the five-point Likert Scale. Moreover, the SUMI method (Kirakowski & Corbett, 1993) measures usability from the user's point of view. It consists of 50 statements using a three-point Likert Scale. Zub and Eessaar (2008) proposed a novel pattern-based usability evaluation method which uses Analytic Hierarchy Process (AHP) and provides numerical results.

While the methods mentioned do not propose any specifications for evaluation of e-learning systems, adjusted to people with hearing loss, Alsumait and Al-Osaimi (2009) developed an expanded heuristics evaluation for those systems. It comprises of measuring the usability, as well as pedagogical effectiveness, and provides qualitative results. Moreover, Ohene-Djan and Naqvi (2005) enable the measurement of usability and efficiency of the system for deaf and hard-of-hearing children a qualitative research with results in nature. A new methodology for testing the usefulness of e-material for participants was developed within the project Synergia (Vrettaros et al., 2010). Effectiveness is evaluated by testing participants' ability to integrate e-learning content into real life. Furthermore, Šnajder et al. (2007) developed the AdaPEI method, on the basis of Sonwalkar's method, for measuring pedagogical effectiveness of e-learning courses, adapted to people with disabilities without evaluating usability or technical metrics of the system.

In the evaluation approaches to e-learning systems for deaf and hard of hearing described above, we can see a lack of evaluation methods that are tailored to e-learning systems for people with hearing loss. The most common practice is to evaluate those systems with evaluation methods which are in use for e-learning systems that are not prepared especially for people with special needs. The

methods do not take into account all the design considerations that are followed when e-learning courses are adjusted for the deaf and hard of hearing. For instance, the AdaPEI method does not cover all aspects of interaction between the user on one side and the system, teacher and other users on the other side.

Secondly, there is a lack of evaluation methods that capture both pedagogical and usability aspects. Evaluation of usability without an equivalent evaluation of pedagogical effectiveness of e-material is not sufficient. It means that we must design a system that supports students' learning so that they devote a minimum effort to the interaction with the program (Alsumait & Al-Osaimi, 2010). De Villiers (2004) and Dringus and Cohen (2005) emphasized that usability evaluation methods should also estimate pedagogical factors.

We can measure usability and pedagogical effectiveness by combining two or more methods, but there is a lack of a common method comprises of both. Therefore, we developed a model for evaluation on the basis of Sonwalkar's method of Pedagogical Effectiveness Index.

## Evaluation of E-Learning Systems for the Deaf and Hard of Hearing

An evaluation of an e-learning system should cover several aspects — pedagogy as well as usability. To gather the most reliable and relevant information, evaluation methods should consider the needs of users.

### Pedagogical Effectiveness of e-Material

Sonwalkar (2002) proposed measuring the pedagogical effectiveness of online e-learning material with the Pedagogy Effectiveness Index (PEI). We calculate PEI by analysing how many factors of the three determined dimensions that our system comprises. Table 1 shows these dimensions — Learning style, Media, and Interaction — as well as factors that ensure pedagogical richness in learning.

Table 1: Dimensions and Factors for Measuring PEI

Learning style	P <sub>i</sub>	Media	P <sub>j</sub>	Interaction	P <sub>k</sub>
apprenticeship	0,068	text	0,055	feedback	0,066
incidental	0,068	graphics	0,055	revision	0,066
inductive	0,068	audio	0,055	e-mail	0,066
deductive	0,068	video	0,055	discussion	0,066
discovery	0,068	animation	0,055	bulletin	0,066
		simulation	0,055		
Total (weighted)	0,34		0,33		0,33

(Source: Sonwalkar, 2002)

Each factor in the learning dimensions has a weight. The sum of all the weights of factors in a dimension forms the overall weight of dimension. The sum of the latter ones forms PEI. It varies from 0 to 1.

$$PEI = \sum S_i * p_i + \sum M_j * p_j + \sum I_k * p_k \quad (1)$$

because it is:

S – Learning style,

M – Media,

I – Interaction,

Indexes define factors of individual dimension:  $i = 1$  to  $5$ ,  $j = 1$  to  $6$ ,  $k = 1$  to  $5$ ;  $\sum$  presents a sum.

When we analyse how many factors are included in our system, we get a final PEI result. For every *missing* factor in our system the final result is *lower*.

### **Pedagogical Richness and Usability of e-Material for the Deaf and Hard of Hearing (PRU method)**

We tailored Sonwalkar's (2002) method to e-learning systems for people with hearing loss. We developed the Pedagogical Richness and Usability (PRU) method. The basis for development of the new evaluation method was Learning Management System for the Deaf and Hard of Hearing – LME4D.

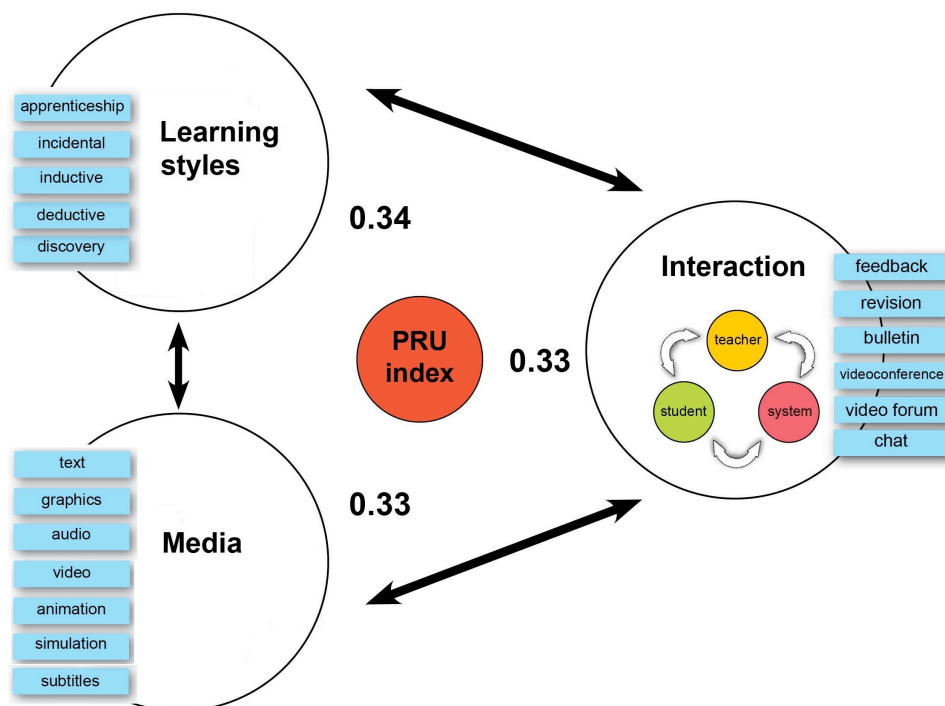
LME4D is based on a custom modified version of Moodle and is comprised of three parts; contextual, communicative and collaborative. The contextual part consists of several sections where users can get advice for searching for a job, writing a job application letter and curriculum vitae (CV). The whole content was translated into Slovenian sign language using high-quality sign language interpreter videos. We used a multimodal approach where video, audio and subtitles are provided. Communication within the system was managed by videoconference, chat and innovative video forum, specifically designed to the needs of deaf people. As a result, we provided communication among users in sign language. Users can also do exercises, quizzes and assignments. We provided a glossary for deaf and hard of hearing users with a transparent Sign Language Interpreter Module (SLI Module) (Debevc et al., 2010). The video does not alter the learning process, because it is shown on the user's initiative over the existing Web page. An example of an e-learning unit in LME4D using a transparent video for glossary is shown in Figure 1.

Figure 1: E-learning unit in LME4D



The PRU method provides a model for measuring optimal pedagogical richness and usability of e-learning course for deaf and hard of hearing. Figure 2 shows the structure of the PRU method and interdependence of three dimensions — learning styles, media and interaction — which were taken from Sonwalkar's idea.

Figure 2: Dimensions and Factors of the PRU Method



These dimensions are equally weighted, and the weights of factors are balanced within the dimensions. It means that each learning style weighs 0.068, media element 0.047 and interaction factor 0.055. Improvements were made within dimensions *media* and *interaction*. We extended the dimension *media* with the factor *subtitle*. Thus, we provided a multimodal approach for deaf and hard of hearing users. Whether we merge sound, video with signing and/or subtitles in video recording, we enable users freely to choose which one of those three they will pay more attention to (Debevc & Peljhan, 2004).

In *interaction*, the factors pertaining to the kind of interaction were changed. The factor *feedback* was specified as the connection between a teacher and a student when they communicate through *e-mail*. The factor *revision* was defined as interaction between a teacher and a student not specified in *feedback*, because when interactive tasks are done, the teacher checks the correctness of tasks. *Bulletin* covered the interaction between a user and a system where a student gets response from a system. We installed quizzes here. Discussion was divided into separate factors: *videoconference*, *video forum* and *chat*. Thus, communication many-to-many among students was assured.

We followed Sonwalkar's method and added a usability aspect. Our experience with the deaf and hard of hearing showed us that they had a low threshold of patience and could easily get bored. Hence, we decided to simplify the testing method and to prepare a concise close-ended questionnaire. It followed the dimensions and factors of the PRU method. We measured the participants' opinion. Questions were formulated concerning two aspects — pedagogical aspect and usability. A five-point Likert scale was used and presented in a response format (1 – strongly disagree and 5 – strongly agree).

The way to calculate PRU index:

1. An average value of each answer is calculated
2. In case there are two or more questions for a factor, an average value of all previously calculated average values of answers is calculated.
3. The calculated value from the previous step is divided by 5, because the maximum value on 5-point Likert scale is 5.
4. The value is multiplied by the weight of a factor from the PRU table.
5. The procedure of the first four steps is repeated for each factor in the PRU table.
6. We sum the new weights of factors within each dimension.

7. We sum the weights of all three dimensions and get PRU index. It varies from 0 to 1.

An E-learning system is pedagogically rich and user friendly when the value of the PRU index is equal to, or greater than, 0.5.

The calculation procedure of the PRU index in formulas follows. Formula (2) represents the calculation of an average value of questions for each factor. The sum of values of two questions is divided by the number of questions. In our case, this means 2. The weight of the factor is calculated by dividing one by the product of the number of factors within a dimension and the number of dimensions (see formula 3). Formula (4) shows the calculation of the PRU index. An average value of questions for each factor is divided by 5 and multiplied by the weight of the factor, which depends on the dimension to which it applies. It is repeated for each factor in dimensions and the sum represents the PRU index.

$$w_1 = \frac{1}{n m_1} \quad w_2 = \frac{1}{n m_2} \quad w_3 = \frac{1}{n m_3} \quad (2)$$

$$q_i = \frac{q_1 + q_2}{2} \quad (3)$$

$$PRU = \sum_{i=1}^5 w_1 \frac{q_i}{5} + \sum_{i=1}^5 w_2 \frac{q_i}{5} + \sum_{i=1}^5 w_3 \frac{q_i}{5} \quad (4)$$

$w_{1,2,3} \dots$  value of weights of factors in the first, second and third dimension

$m_{1,2,3} \dots$  total number of factors (components) in each dimension (learning style, media and interaction)

$n \dots$  total number of dimensions

$q_j \dots$  an average value of the question for one factor

$q_{1,2} \dots$  value of the first and the second question for one factor

$\sum$  presents a sum.

## Conclusion

The PRU method was conceived for measuring the pedagogical richness and usability of e-learning systems, adjusted to deaf and hard of hearing users. Comparing to existing evaluation methods, the PRU method quantifies specifications that evaluation methods for non-adapted e-learning systems do not comprise. It considers the pedagogical, as well as the usability aspect. The result of the method is a PRU index that can vary from 0 to 1. While quantitative results are provided, it also enables qualitative interpretation. An evaluator can specify the weaknesses of the system within learning styles, media and interaction elements.

In the future, we plan to perform an evaluation of our LME4D with the use of the PRU method. Results will assess not only pedagogical richness and the usability of our system, but also confirmation on whether the system assures pedagogically rich learning. The PRU method can also serve as a model and guideline to design e-learning courses for the deaf and hard of hearing and can offer suggestions for their improvements. With the use of the PRU method, weaknesses of the evaluation method will be shown. If necessary, we do not rule out extending the method to include Sonwalkar's summative evaluation instrument. According to the rapid development in the field of e-learning for people with disabilities, we foresee that improvements within the method will be needed in future.

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