MODELLING A FUZZY SYSTEM FOR TEACHERS' TRAINING DESIGN

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Abstract: This paper presents a model, based on fuzzy logic, aiming to support teachers' training design. The complexity of the task of technology utilisation in education, leads the authors to decision to base its adaptive system on fuzzy controller. We shortly describe the system architecture and its functionality. The presentation includes also fuzzy model implemented in the kernel of the system, its components, linguistic variables and values. Further steps for improvement of the system performance are sketched as well.

1 INTRODUCTION

Many researchers and politicians hope that Information and Communication Technologies (ICT) itself will dramatically change the education. But it seems just ICT to be present in the schools is not enough. They are not effectively used, in some cases not used at all. One of the conclusions of the Institute of Prospective Technological Studies report (Cachia et al., 2010) is "*it is necessary teachers to be trained appropriately in order to have effective use of technology in the school*". Although in many countries massive teachers training on ICT were done in recent years (Bulgaria, Romania, etc.), in other (UK) - teacher professional development is embedded in the systems, the expected changes still are not visible. One of the reasons for ineffectiveness is related to the design for teachers training in field of integration of technology in education. In this paper we will focus on the problem and will discuss some possible solutions.

Teacher training is one of the four forms of the professional development. In-service courses format is appropriate and very effective when some innovations are introduced and small number of people are well informed about them (Guskey, 2010). Exactly this is the case with teachers training in field of integration of technology across curricula.

Designing training, the characteristics of professional developments of adult should be kept in mind. It is not enough to build the knowledge for a technology per se. The knowledge about technology is context-dependable. The effective teaching of technology requires an understanding how technology relates to the pedagogy and content. As consequence, the designers of teachers training should aim to build Technological Pedagogical Subject Knowledge (Mishra and Koehler, 2006). More over, it is crucial to respect personal models because personal values (as expressions of personal priorities and positions) are inextricable from making decisions by training designers (Pratt et al., in press). The characteristics of teachers training, which design we would like to support, makes the model very complex. In addition, the model should be adaptable to different technologies, users and their objectives.

In Section 1 we argue our decision to choose the fuzzy logic as base of the approach to cope with the problems. Second section is devoted to the design of fuzzy logic controller. Finally, the aggregation done by the system is presented. The conclusion sketches some further steps in the research and the improvement of the system prototype as well as possible future use of the model and system itself.

2 FUZZY SYSTEM DESIGN

The field, we try to model, is too complex. The

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formal modelling in similar cases is appropriate to be developed through Fuzzy Logic (Zadeh, 1965; Zadeh, 1973) integrated in Expert System. Such model promises to support successfully designers of training. We start the design of the model from ‘catching’ reality in the education: collecting experts’ knowledge, converting it into the conceptual abstract model, deriving the conclusions based model and using it to support designers.

2.1 Components Identification

The identification of the components is based on collecting experts’ understanding on importance of the factors related to teachers training in digital technologies for education. There were chosen mainly components that affect to great degree effective use of ICT in their school practice.

In this phase 23 experts from Bulgaria was involved. Fifteen experts were most active participants. They are experts in field of training teachers for effective integration of ICT in education.

Methodology used to collect experts opinion follows the structured participative approach called Group Concept Mapping, applied successfully in solving similar problems (Stoyanov and Kirschner, 2004; Trochim, 1989; Wopereis et al., 2005). The approach is very powerful combining both qualitative and quantitative methods, but it is useless without expert ideas and opinions. The Group Concept Mapping procedure consists of four steps. At first step the experts were asked to brainstorm which are most important factor during the teachers training, reflecting on effective use of the ICT in school practice. Then, they send back the generated by them list. The lists were collected and joint. During the second step the list of all generated factors was sent to the experts. They were asked: to group the factors; to rank factors into each group (according to their importance to relation with future effective application of ICT in teachers practice); to name the groups; to rank the groups (according to their importance to relation with future effective application of ICT in teachers practice).

After detailed analysis of the focus group brainstorming, sorting and rating main components of the model, a triangulation with parallel analysis with two experts was then made. Four top factors, rated by participants, are concluded to be main components of the model namely: Methodology, Technology, User, Objectives.

2.2 Defining Linguistic Variable

The participants of Group Concept Mapping listed main properties related with each of the factors detected as important characteristic of the component. On their base variables of each component are created (Stefanova and Boytcheva, 2010). Table 1 presents methodology component linguistic variables and values.

Table 1: Methodology linguistic variables and values.

Variable	Values
Learner activity (LA)	Very Low, Low, Average, High, Very High
Learners style correspondence (LSC)	Fully, Almost, Slightly, None
Practice orientation (PO)	Very Low, Low, Average, High, Very High
Technology Integration (TI)	Fully, Almost, Slightly, None
Technology present (TP)	Very Abstract, Abstract, Concrete, Very Concrete

The *Objectives* component has linguistic variables Skills (S), Knowledge (K), Competence (Cp) and Educational Level (EL). The *User* component has following variables: Qualification (Q), Motivation (M), Personal Reasons (PR), and Professional Factors (PF). The *Technology* component variables are Complexity (Cx), Cost (C), Functionality (F), and Utilization (TU). Our main goal is to make an inference about Technology Utilization variable, based on the model and rules.

2.3 Defining Rules

The relations between components and their linguistic variables are defined on based on experts’ opinion. They are presented on Figure 1.

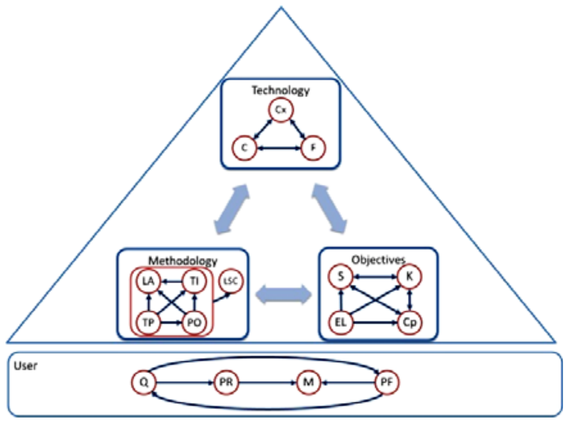

Figure 1: Relations between linguistic variables.

In order to make the inference about technology utilization it is necessary to choose in advance the components priorities: how the user orders by importance the component in the design of training. Thus we can have methodology, technology or objective centred training approaches. On the Figure 2 the methodology centred approach dependences are presented. In this case for different combinations of the linguistic variables values for Methodology component we can infer different combinations of values for Objectives component.

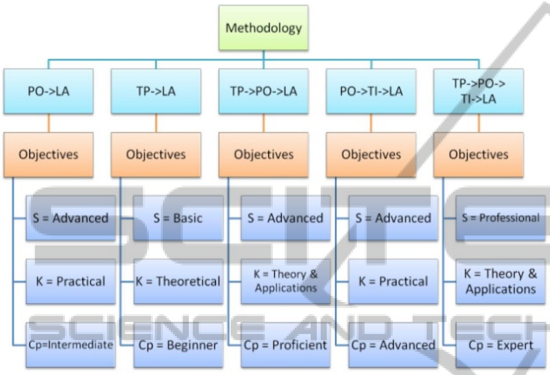

Figure 2: Methodology Centric Approach: Inferred values for Objectives.

On such base rules were generated using Methodology variables values combinations for prerequisites and setting values for objective component variables as conclusion. However most of the rules use not only single component variables as prerequisites. About 75 rules were developed by experts in the current stage of the project.

Triangular versions membership functions were used to represent variables values. In inference engine centroid technique is used.

3 AGGREGATION OF TRAINING DESIGN MODELS

The designed model is used to build the fuzzy system (Stefanova and Boytcheva, 2011) supporting design of training models. One of its important functionality is to compare users' profiles in the training group. This task can't be performed as a simple production of average values, due different Training models and complex interrelations between linguistic variables. The comparison procedure includes usage of priorities for different linguistic variables. These priorities are defined explicitly and implicitly. The explicit priorities are settled during the user registration in his/her profile, choosing preferences for training method – methodology, technology or objective centred. The implicit priorities are based on user's performance history. Depending on linguistic variables priorities we associate to each linguistic variable corresponding weight.

We are comparing separately values of each component Methodology, Technology, User, Objectives (Figure 3).

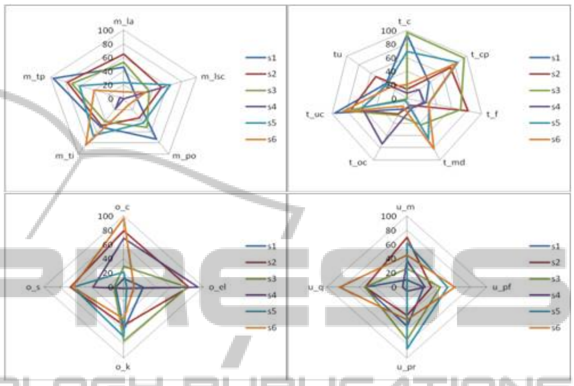

Figure 3: Distances between values of linguistic variables for each of the components of the model for six training design models.

The comparison of multiple users' models is quite complex task. That is why we are comparing rather individual values than the sum effect of them, because the data are too disperses (Figure 4).

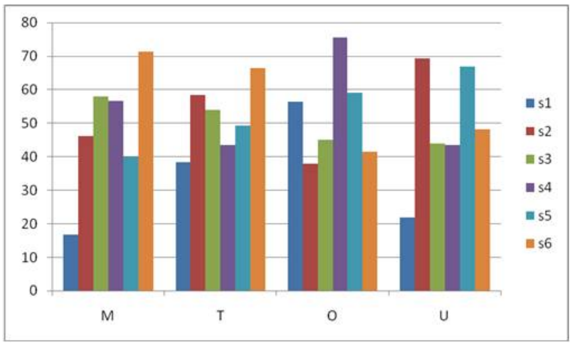

Figure 4: Comparison betwen total vatiables for each component for six training design models.

Using the weight for each different variable in the component we are calculating the total value of each component. For instance for methodology we have equation (1).

$$M_i = w_1 m\_la_i + w_2 m\_lsc_i + w_3 m\_po_i + w_4 m\_ti_i + w_5 m\_tp_i \quad (1)$$

Similarly we calculate the total effect of Technology (T), Objectives (O) and User (U). Then we find the average values of totals for each component and the deviations for Training design models from it (2) and (3).

$$M_{avg} = \frac{\sum_{i=0}^{n} M_i}{n} \quad (2)$$

$$M_i^d = M_{avg} - M_i \quad (3)$$

The final evaluation of models is the sum of deviations of each model totals from the average (4).

$$E_i^d = M_i^d + T_i^d + O_i^d + U_i^d \quad (4)$$

Setting in advance the thresholds (t) the final scores for two models E_i and E_j are considered the same if their difference is bellow threshold.

$$| E_i^d - E_j^d | < t \quad (5)$$

The final result of comparison of multiple user training design models is clustered of similar models depending on thresholds neighbourhood (Figure 5).

There are two cases:

- One of the clusters dominates – in this case we choose its aggregated training model for the whole learning group.
- None of the clusters is dominant – then we split the group on subgroups corresponding to clusters and perform aggregated training model for each cluster individually.

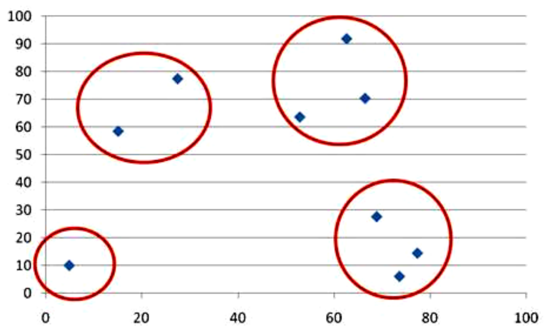

Figure 5: Clustered space to four training design models.

4 CONCLUSIONS

In this paper we present work in progress. On the current stage of the project we need to tune the linguistic variables values and to test different membership functions and inference engine techniques for generating output values. The final decision which of them fits best to our domain representation would be made on the testing results base. Further research steps will be followed by testing and validating the model with available data for already passed teachers' trainings. On the results base, the model will be refined. In order to approve the proposed approach applicability into practice, the prototype of the build fuzzy system will be tested with teachers and instructional designers of teachers' trainings.

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