Abstract—Currently, electronic services are being applied in numerous fields of social life. One of them, where technologies are gaining an important and unsubstitutable position, is education. In the last decade eLearning has become a frequently used term. After starting quantitative increase of eLearning services, it is time qualitative factors were followed, mainly the effectiveness of the educational process. The effectiveness of the educational process is given by such factors as learner’s intelligence, prior knowledge, level of motivation, stress, self-confidence, and learner’s cognitive and learning style. The process of instruction supported by ICT is considered suitable and beneficial for learners of all styles. The reason is it offers a wide range of activities which can be aimed at any learning style and used by any teaching style instructor. The possibility of individualization of the educational process from the both students’ and teachers’ point of view is the greatest advantage of using software applications in education.

Keywords—eLearning, ICT, LCI, Learning Combination Inventory, Learning Management System, learning pattern, learning style, virtual learning environment.

I. INTRODUCTION

Information and communication technologies (ICT) have reached a crucial position. Nowadays we can meet with them in numerous fields if human activities.

Ten years ago a new term appeared — e-learning (eLearning). This term has not been defined precisely thanks to its not long, only a ten-year long history. Resulting from the author’s point of view, there exist numerous definitions.

The term of e-learning arose similarly to other ones, which appeared in the last decades and relate to the Internet in various fields of human activities, e.g. e-mail, e-banking, e-commerce, e-business, e-book, by joining the word learning and prefix e-.

The word learning covers all activities relating to the process of education, instruction, cognition and forming knowledge. The e- prefix is used as electronic equivalent of existing products or services. It indicates relation to Internet.

Putting the prefix and word together (i.e. prefix e - which means electronic, and learning, which covers the process of forming knowledge), another term arises which means a modern way of education using computing technology and appropriate applications, i.e. the educational process supported by information and communication technologies. [1]

Although computer programmes for education have been used since 1960s, only the Internet and web applications enabled their mass spread and use. During the last decade eLearning found its position in both gradual and lifelong education.

Large experience gained in the process of ICT implementation in education received lately has started new discussions. Instead of technical problems, new technologies and approaches the questions on the theory of learning and teaching styles are the topic of the day. They play an important role in the process of instruction, especially if it is managed by an Learning Management System (LMS). [1]

LMS provide a wide range of tools available to authors of eLearning courses which can accommodate all learning styles, and students choose those activities which suit them best.

The effectiveness of the educational process is given by many factors, e.g. learner’s intelligence, level of knowledge, motivation, self-confidence, and learner’s cognitive and learning style. Teacher’s teaching style and the matches/mismatches with students’ learning styles influence the efficiency of the educational process to a large extent. Some authors [2] say (instead others) that mismatching can cause further educational problems. On the other hand, if the same teaching style is used repeatedly, students become bored. [3]

The process of instruction supported by ICT may become suitable and beneficial for learners of various styles. The reason is it offers a wide range of tools and activities which can be tailored to any learning style and used by any teaching style instructor. The possibility to individualize the educational process from the both students’ and teachers’ point of view belongs to valuable advantages of eLearning. [1]
II. A FLEXIBLE MODEL OF THE ICT SUPPORTED EDUCATIONAL PROCESS REFLECTING INDIVIDUAL LEARNING STYLES

Wide possibilities offered by modern technologies generate new questions. Numerous educators face the problem whether the educational process which is supported or managed by ICT and tailored to the preferred student’s learning style is more efficient than if the learning style is not taken into account.

Answer to this question is been discovered within the project "A flexible model of the ICT supported educational process reflecting individual learning styles". The project is currently solved by a joint team of researchers from the Faculty of Informatics and Management and Faculty of Education, University of Hradec Králové, by specialists in informatics, educational science, didactics and psychology. [4]

The main objective of the project is to find out whether using ICT-supported methods of instruction which reflect individual learning styles results in significantly higher level of students’ knowledge in comparison to the traditional, majority (i.e. non-individualized) way of instruction. The main evaluative criteria are the quality, meaningfulness, effectiveness and limits of ICT/LMS implementation in the instructional process considering individual learning styles, and present proposals to its optimal contribution and extent. [5]

III. LEARNING COMBINATION INVENTORY

The project "A flexible model of the ICT supported educational process reflecting individual learning styles" proceeds from the assumption that it is important for a student to be aware of his/her learning style, know what his/her strengths and weaknesses are and be provided a variety of instructional methods to choose the most suitable ones.

In the field of educational science and psychology the theory of learning styles is properly worked on. There exists a wide range of tools to define individual learning styles, both national and international. Some of these tools are demanding for evaluation, and only experts are expected to work with them. Within the research another tool was developed, easy to apply and processing the data automatically.

The research team has decided to use the "Learning Combination Inventory" (LCI) by Christine A. Johnston. Johnston created her model on the principle of "unlocking the will to learn". It emphasizes not the product of learning, but the process of learning, and focuses on how to unlock and what unlocks the learner’s motivation and ability to learn, i.e. she tends to discover ways to achieving learner’s optimum intellectual development. [6]

LCI is a statistically valid and reliable instrument that measures the degree to which a person uses four interactive patterns of learning and operation. Johnston distinguishes four basic patterns:

- Sequential Processor;
- Precise Processor;
- Technical Processor;
- Confluent Processor.

The word combination in the name of the inventory is used because the author states each of us uses a combination of all patterns. Each of them participates in the individual's process of learning to some extent, while some of them are preferred, others rejected. Some people prefer one pattern which other people reject, or they use more patterns, even all four ones.

Unlike other similar tools the LCI is easily and clearly evaluated. It consists of 28 closed questions supported by three open ones, which serve for verifying the determined patterns.

These were the most cogent arguments in the decision-making process which tool suits best to the project purposes.

IV. THE QUESTIONNAIRE MONITORING PREFERRED FORMATS OF STUDY MATERIALS

In the first phase the project started with a pre-activity which aimed at detecting whether student’s choice of a certain type of study materials and tools is influenced by the detected pattern.

For this purpose a simple questionnaire consisting of nine questions was prepared where students defined their relation to following types of study materials:

- books and professional literature;
- electronic study texts;
- presentations;
- video-recorded lectures;
- animations;
- self-tests;
- hands-on tasks and examples
- other supportive materials, e.g. dictionary.

Students were asked to define what type of study materials they prefer when preparing for lessons during the term and studying for exams.

Single items were in the form of statements and evaluated by a five-degree scale, e.g. question N. 6:

6. If there exists a full eLearning support for the subject containing animations, I used them:

- never
- hardly any time
- sometimes
- almost always
- always

The questionnaire was distributed during the summer term in 2009/10 academic year to 107 students of the Faculty of Informatics and Management, University of Hradec Králové, in study programmes Applied Informatics and Information Management, who also filled in the LCI. So, consequently mutual relations can be researched among single patterns and preferred types of study materials.

The received results proved some expectations.

Today’s students seldom work with printed sources. Only 1% of students almost always buy the recommended books,
one third (33%) does this sometimes and two thirds (66%) do not buy books at all. This fact could be influenced by the price. Nevertheless, similar results appeared in question dealing with borrowing printed sources which are available in university library. Only 7% of students borrow books regularly, half of them (48%) sometimes and 45% never or hardly any time borrow the recommended books. (Figure 1)

As following responses show, today’s students mostly prefer electronic study materials.

In electronic courses various types of study materials are available, mostly in HTML format, PowerPoint presentations summarizing basic structure of the course, topic or subject, and some supportive tools, e.g. e-dictionary.

Vast majority of students (87%) always and almost always works with electronic study texts, 10% use them sometimes. Nearly all students (93%) always and almost always use presentations of the topics. Other types of study materials (e.g., dictionary) are used in a considerably little extent. 42% of students always and almost always use them and another 41% sometimes. (Figure 2)

Authors of eLearning courses include various feedback-providing tools, such as self-tests and numerous hands-on examples or tasks. Although these are to help students understand the problem, they are used less frequently than study texts and presentations. More than two thirds of students (68%) always and almost always use the provided examples. Self-tests are even less used. More than one fourth never and hardly any time uses them, 39% sometimes and only fewer than one third (31%) always and almost always work with them. (Figure 4)

In some eLearning courses animations, video-recorded lectures or case studies are available which make some difficult parts of learning content easier to understand. The research proves these materials are used less than presentations or study texts. Animations are more frequently used; more than half of students always and almost always uses them (53%) if they are available. Video-recordings, which are more demanding to be prepared and can be found only in selected eLearning courses, are less popular among students. More than one third of students (38%) never and hardly any time uses them, one third (33%) sometimes and even fewer students (29%) always and almost always work with them if they are available. (Figure 3)
The value higher than 24 means student prefers the given pattern in his/her process of learning; the value between 18 - 24 means this pattern is tolerated, accepted without problems; and the value lower than 18 means student rejects the given pattern.

Consequently, using the NCSS2007 statistic software, relations between single patterns and types of study materials were detected. Results are presented in Table I.

According to the results, students preferring the Sequential Processor prefer electronic study texts, books and professional literature, video-recorded lectures and presentations; they reject self-tests and other supportive materials, e.g. dictionaries.

Students preferring the Precise Processor work with books and professional literature, animations, examples, electronic study texts and other supportive materials, e.g. dictionary; they do not like video-recorded lectures.

Students preferring the Technical Processor often use animations and video-recorded lectures; they do not work with electronic study texts, other supportive materials, e.g. dictionaries and presentations.

Students preferring the Confluent Processor prefer books and professional literature and self-tests; they do not use electronic study texts, video-recorded lectures, presentations and other supportive materials, e.g. dictionaries.

![Figure 5: Example of LCI results](image)

<table>
<thead>
<tr>
<th>Student</th>
<th>Sequential</th>
<th>Precise</th>
<th>Technical</th>
<th>Confluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>27</td>
<td>16</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td>B</td>
<td>23</td>
<td>17</td>
<td>29</td>
<td>31</td>
</tr>
<tr>
<td>C</td>
<td>20</td>
<td>17</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>D</td>
<td>23</td>
<td>24</td>
<td>26</td>
<td>18</td>
</tr>
<tr>
<td>E</td>
<td>24</td>
<td>27</td>
<td>25</td>
<td>23</td>
</tr>
</tbody>
</table>

**TABLE I**

<table>
<thead>
<tr>
<th></th>
<th>Sequential</th>
<th>Precise</th>
<th>Technical</th>
<th>Confluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Books</td>
<td>0.11</td>
<td>0.27</td>
<td>0.05</td>
<td>0.11</td>
</tr>
<tr>
<td>Borrow books</td>
<td>-0.01</td>
<td>0.34</td>
<td>0.12</td>
<td>0.22</td>
</tr>
<tr>
<td>El. study text</td>
<td>0.12</td>
<td>0.11</td>
<td>-0.18</td>
<td>-0.17</td>
</tr>
<tr>
<td>Presentation</td>
<td>0.01</td>
<td>0.01</td>
<td>0.11</td>
<td>-0.10</td>
</tr>
<tr>
<td>Video</td>
<td>0.09</td>
<td>-0.03</td>
<td>0.20</td>
<td>-0.16</td>
</tr>
<tr>
<td>Animation</td>
<td>0.01</td>
<td>0.24</td>
<td>0.23</td>
<td>-0.02</td>
</tr>
<tr>
<td>Selftest</td>
<td>-0.04</td>
<td>0.11</td>
<td>0.12</td>
<td>-0.14</td>
</tr>
<tr>
<td>Examples</td>
<td>-0.11</td>
<td>0.00</td>
<td>-0.12</td>
<td>0.09</td>
</tr>
<tr>
<td>Dictionary</td>
<td>0.05</td>
<td>0.12</td>
<td>0.02</td>
<td>-0.04</td>
</tr>
</tbody>
</table>

**VI. APPLICATION SUPPORTING INDIVIDUAL LEARNING STYLES**

Currently, Internet applications provide the electronic support of the educational process. Learning Management Systems (LMS), or Learning Content Management Systems (LCMS) are usually used for distribution of study materials, communication, feedback and management of the process of instruction.

These applications provide numerous tools which may suit students with various learning styles. Nevertheless, as in the face-to-face instruction, one “universal” course is designed which is expected to suit most students, or it reflects the teaching style of the designer.

But modern approaches enable to create interactive applications which react to user’s instructions. That is why the research team decided to apply a similar approach to individualization of eLearning courses.

The main idea is based on adding an application to running courses, which will arrange various types of study materials in order according to student’s individual preference.

Before students start the work in a course, they will take the LCI and set the results, if received before, in the application. The results are in the easy form, they are four figures meaning the sequential, precise, technical, confluent pattern, where -1 means reject, 0 means tolerated, 1 means preferred pattern. The application puts the study materials on the entry page in such order which reflects the individual learning style. The most appropriate materials are located on the top left position, the rejected materials on the lower place. Above all, the preferred types will by emphasized in colour and size of the pictograms. This approach requires form authors of study materials to evaluate each of them according to the same criteria as students were evaluated, i.e. the author matches each material to the type of learning style (pattern) it suits best using the figures -1, 0 and 1.

Currently, a team of Ph.D. students is creating the application within the project of specific research “Application supporting the flexible model of the educational process”. The application will be used in the LMS WebCT. After piloting, it can be adjusted to using in other learning management systems.

**VII. CONCLUSION**

University education, which has been changing under the influence of latest technology development, can be researched from various, different points of view. Currently it is obvious that education supported by ICT enables easier and more complex realization of the instructional process, it offers choice of place, time and pace for studying. At the same time the ICT-supported education allows an individual approach to students preferring various learning styles.

**REFERENCES**


