Matching learning styles to different type of DSP laboratory experiments

Radojka Krneta, Marjan Milošević, Djordje Damnjanović, Danijela Milošević
Faculty of Technical Sciences Čačak, University of Kragujevac
Čačak, Serbia
radojka.krneta@ftn.kg.ac.rs

Abstract— Development of the blended learning environment integrating online and hands-on laboratory practices together with learning of theoretical concepts within engineering course in DSP is described in this paper. The student surveys concerning to Kolb’s inventory of learning styles and preferred type of lab exercises are carried out. Survey results were discussed from the point of matching different learning styles with preferred type of DSP lab exercises.

Keywords- DSP course; on-site experiments; remote experiments; blended learning environment; learning style

I. INTRODUCTION

As a rule, learning theoretical concepts of digital signal processing (DSP) is difficult for the engineering students. This difficulty is a result of the gap between understanding mathematical formalisms of these concepts and student’s abilities to connect these theoretical concepts with practical engineering applications. In order to enhance the teaching process for our engineering students we have developed DSP laboratory towards the usage of blended learning environment integrating online and hands-on laboratory practices together with theoretical DSP concepts similar to solutions described by several authors [1] - [9].

Individual differences in cognitive learning styles e.g. student's mode of thinking, perceiving, remembering, or problem solving are quite obvious when teaching science or engineering. The variation is reflected in fact that some students need to visualize the task before starting, some approach learning and teaching rather sequentially or rather randomly, some would work quickly or even deliberately, some are passionate of immediate "try in the lab", while others would primarily focus on mathematical structure and find theoretical outputs before real practice. This indicates that multiple approaches are needed to achieve the best for students. We strive to help our engineering students, who generally learn by active experimentation, develop, to some extent, the abilities of abstract conceptualization, through innovative teaching technique and enhance their interest in a learning theoretical concepts of DSP. Also, we foster the class and web discussions to enhance collaborative work during student’s activities on on-site and remote laboratory exercises and solving their homework. In this way the simulation of real work engineering environment is done.

While performing experimental online learning, a learner can create his/her own learning path as a ‘walk through’ modularized learning activities by designing exploratory research questions, conducting remote experiments, finding answers, making interpretations and discussing results in the community. In order to accommodate different learning styles, we combined remote LabVIEW exercises with class exercises based on Matlab and hands-on lab exercises on specific NI hardware in addition to DSP theory classroom teaching.

In order to evaluate of our blended learning approach in DSP teaching, we have conducted student surveys concerning matching of different learning styles to different type of laboratory DSP experiments. For this purpose we have conducted two separate online surveys among groups of our postgraduate engineering students attending the course in Advance Technics of DSP. First survey was related to Kolb’s inventory of learning styles. Second survey was related to preferred type of lab exercises (Matlab simulations, Simulink simulations, LabVIEW simulations, on-site hardware experiments, remote hardware experiments) concerning better understanding of DSP theory concepts and more efficient acquisition of skills and practical knowledge as well as concerning the most useful scenario, considering methods (individually, collaboratively) and place (on-site, remotely) of learning.

II. MEETING DIFFERENT LEARNING STYLES THROUGH INTEGRATION OF ON-SITE AND REMOTE DSP EXPERIMENTS

Kolb’s learning style theory identifies four types of learning styles [10]:

- Concrete Experience
- Active Experimentation
- Abstract Conceptualization
- Reflective Observation

Divergers (Type 1) prefer to learn from the actual experience and reflective observation. They are creative, efficient to generate alternatives, to identify problems and to understand people.

Assimilators (Type 2) learn through the abstract conceptualization and reflective observation. They work very well with a great variety of information, placing them in logical
order. They are generally more interested in the logic of an idea than in its practical value.

Convergers (Type 3) like to learn through abstract conceptualization and active experimentation. They appreciate to do practical applications of ideas and theories, they have good acting in the conventional tests, they use the deductive reasoning and they are good to identify and solve problems and to take decisions.

Accommodators (Type 4) prefer to learn from active experimentation and concrete experience. They adapt well to immediate circumstances, they learn placing the “hands on” and facing risks.

Traditional teaching of engineering mostly focuses on formal presentation of the material (lecturing). That style is appropriate only for the Type 2 students. To reach all the types, the teacher needs to expose the relevance of every new study topic (Type 1), to present the basic information and methods related with the topics (Type 2), to supply opportunities to practice the methods (Type 3) and encourage the exploration of applications (Type 4) [11].

An extended approach to the teaching process from the standpoint of diverse student’s learning style and his motivation level was considered by Milosevic et al. [12]. Beside above basic questions, specifications like Types of learning, Types of thinking, Useful student’s activities, Task, questing and testing and, finally, Instructor role and type of E-Support could be associated to each specific learning style. For example, Convergers are distinguished by practical learning, they think trough analogies, useful activities for them are skills practicing, implementation of ideas and peers feedback, their favorite tasks are practice examples, implementation and analyses of implementation, instructor role should be the coaching, practice and giving the feedback.

In order to accommodate different learning styles of our postgraduate engineering students, we combined remote LabVIEW exercises with class exercises based on Matlab and hands-on lab exercises on specific NI hardware in addition on DSP theory classroom teaching. For the evaluation of our approach we have conducted student surveys concerning matching of different types of learning styles to different type of laboratory experiments.

The on-site hardware experiment regarding noise cancellation was carried out in the NI LabVIEW FPGA programming environment (“Fig. 1”) by using adaptive LMS algorithm [13] – [15]. This is a good example of learning how adaptive LMS algorithm can be used in practice, i.e. how the theoretical DSP concepts learned in the classroom are ultimately implemented in a real time embedded DSP system.

Web-based remote experimentation assists remote users to develop skills that deal with real systems and instrumentation with additional advantage of providing broader access to expensive specialized equipment at any time and from any location.

The combined use of connected FPGA/PC hardware and appropriate software may open a way to develop a remote multi-user time-sharing system for hardware experiments, where students at remote terminals can perform actual experiments using real hardware equipment shown in “Fig.1”, remotely from home or students residence [5].

Lab View software package has its internal web-server supporting web publishing of the created models and algorithms. By using web publishing tool option we assign the URL address to our application of noise cancellation. The given result of remote hardware experiment on the remote user side is the same as the one carried out as on-site hardware experiment.

Integration of remote laboratory experiments into Moodle learning management system is carried out with the aim of time scheduling and supervision of students’ experiments sessions [9], [16]. A new Moodle block - Remote LabVIEW (RLV) is created [17], allowing time scheduling when students are supposed to access remote experiment.

III. SURVEYS RESULTS CONCERNING LEARNING STYLES AND PREFERRED TYPE OF DSP LAB EXERCISES

In order to test whether learning styles affect the preferred form of exercises, an online survey was constructed by Krneta et al [18]. It consisted out of thirteen items, presented in a concise form, using Moodle’s Questionnaire module. A 4-item Likert scale was used for first eight items. The group of 22 students was involved in the research. The used items are given in Table I. A four-item Likert scale was used for first eight items. For items 9-13, a numbers from 1 (Matlab) to 4 (Hardware experiment) was assigned to each of choice.

Survey results showed that for better understanding of theory concepts students prefer LabVIEW, since more than 90% rated this lab exercise as helpful. MatLab and Simulink got similar results, while hardware experiments shown as helpful in about 70% of cases. For acquiring of practical knowledge students also mostly preferred LabVIEW, again over 90% „helpful“ rates.

![Fig. 1 The laboratory environment for LMS adaptive algorithm hardware experiments](image_url)
For better understanding of theory concepts in Advanced Digital Signal Processing course the most helpful are: (rate with numbers from 1-4, 1 not helpful at all, 2 of very little help, 3- helpful, 4- very helpful )

|---|----------------------|-------------------------|------------------------|------------------------|

For efficient acquisition of skills and practical knowledge in Advanced Digital Signal Processing the most helpful are: (rate with numbers from 1-4, 1 not helpful at all, 2 of very little help, 3- helpful, 4- very helpful)

|---|----------------------|-------------------------|------------------------|------------------------|

The most useful scenario, considering methods and place (check one experiment type for every item)

<table>
<thead>
<tr>
<th></th>
<th>Matlab experiment</th>
<th>Simulink experiment</th>
<th>LabVIEW experiment</th>
<th>Hardware experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. In the lab it is most useful to learn individually with</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. At home, doing remote experiment individually using</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. In lab, with teacher’s assistance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. At home, doing remote experiment with teacher’s online help</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. In lab, working in group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In third items category, for item 9, hardware experiment was most preferred with about 50% votes. Item 10 showed that about 50% of students prefer Matlab and similar was with item 11.

At item 12, equal preference was shown for Matlab and LabVIEW, about 40% for each. At item 13 almost 50% of students preferred hardware experiment, followed by Matlab (25%), LabVIEW and Simulink.

A Kolb’s inventory [19] has been conducted among 22 students who exercised on-site and remote DSP experiments. It showed up that there were three student groups with different learning style, very unequally distributed: convergers (14), assimilators (4), accommodators (4) and no divergers.

To proceed with the research, a regrouping had to be made to gain more balanced grouping in order of getting valid results. Therefore, all students were grouped into two cohorts according to the learning style: convergers and the others.

Then, an ANOVA analysis was conducted for these two groups, regarding every particular answer. The analysis is done using MS Excel Data Analysis Plug-In.

The null hypothesis was set as following: there is no significant difference among groups regarding the preferred learning techniques: between Convergers and other types.

The p-value and Fcrit were checked for every learning/teaching technique, according to the questionnaire. The p-value threshold was set to 0.05. Only results with p-value less than threshold, were considered and then the F value was compared against the Fcrit. In the Table II there is the results from ANOVA, considering the ninth questions (What is in the lab the most useful to learn individually with).
**Table II: ANOVA Analysis of the Item 9**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Count</th>
<th>Sum</th>
<th>Average</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>OTHERS</td>
<td>8</td>
<td>18</td>
<td>2.25</td>
<td>1.928571</td>
</tr>
<tr>
<td>CONVERGERS</td>
<td>14</td>
<td>50</td>
<td>3.571429</td>
<td>0.571429</td>
</tr>
</tbody>
</table>

**ANOVA**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>Df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>8.88961</td>
<td>1</td>
<td>8.88961</td>
<td>8.495191</td>
<td>0.008569</td>
<td>4.351243</td>
</tr>
<tr>
<td>Within Groups</td>
<td>20.92857</td>
<td>20</td>
<td>1.046429</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>29.81818</td>
<td>21</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The complete results have shown a significant difference between Convergers and others. Convergers mostly preferred experiments with hardware and with LabVIEW, and other styles representatives mostly preferred Matlab and Simulink. That may be taken as an indicator that these two kinds of experiments are well mapped with Convergers learning style. According to Milosevic et al [12] the most convenient online support for students Convergers is in the form of applets, computer animation and simulation and virtual experiments, so described blended delivery mode for teaching and learning of this DSP course is right choice for the enhancement of the learning process.

Therefore, the learning style may have strong influence to the specific way of learning in this course. It is up to be further investigated in what extent this difference occurs when more learning styles are present and larger number of students involved in survey.

**IV. CONCLUSION AND FUTURE WORK**

The extensive survey was conducted to test what are the preferred forms of DSP lab exercises by combining the questionnaire items on usability on understanding of theory concepts and practical skills and knowledge on DSP course. As expected, the obtained results showed that for the most of surveyed students preferred hardware and LabVIEW experiments which obviously indicated that these two kinds of experiments are the most suitable for engineering students as them distinguished by practical learning and useful activities for them are skills practicing. Results of survey concerning preferred type of lab experiments shown that for better understanding of theory concepts students prefer LabVIEW, since more than 90% of examinees rated this lab exercise as helpful. Matlab and Simulink got similar results, while hardware experiments shown as helpful in about 70% of cases.

Based on the obtained results concerning the matching specific learning style to preferred type of lab exercises there was seen that Convergers mostly preferred experiments with hardware and with LabVIEW, and other styles representatives mostly preferred Matlab and Simulink. It is up to being further investigated in what extent this difference occurs when more learning styles are present and larger number of students involved in survey.

Additionally, the dominating share of Convergers might not be coincidence specific for this student generation. It should be observed if the population of this profile is in general consisted mostly out of Convergers. If that turns to be right, the way of teaching and learning in this course should be further adjusted to this particular type of learners.

We plan to use this research results as reference point for further research that would include a larger student sample. Then we expect to get more details about students’ experiments preferences and its relationship with learning styles.

**ACKNOWLEDGMENT**

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**REFERENCES**

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