

The Application of Neural Networks to the Process of Gaining and Consolidating the Knowledge

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Abstract—The e-learning course is one of the most efficient and promising didactic policies. It must be grounded on the revision because it was proved that it enhances the long-term memory. However, human mind is not a uniform phenomenon. Each man memorizes and learns in a different manner. The purpose of the intelligent e-learning system presented in this paper is to teach orthography and this system is based on the multilayer neural network. Such structure enables a learner to adjust the crucial period between revisions to personal learning habits and policy.

Keywords—*e-learning, neural network, orthography.*

1. Introduction

Owing to the modern information and communication technologies in education (ICT) a teacher is given a great opportunity to prepare his/her students to deliberate and controlled dealing with the available information.

The functioning educational policy, grounded on so called 'just in case learning', is not efficient enough [1]. It helps to gain knowledge, but the extent of the practical application of that knowledge is limited. Learners are aware of this fact and lack a commitment to learning, what worsens the entire didactic process. Hence, according to e-learning the 'just in case learning' should be replaced with methods and policies which:

- are adjusted to suit the learner's needs ('just for me' policy),
- are provided exactly when they are necessary ('just in time' policy),
- enable a learner to acquire enough knowledge ('just enough' policy).

The e-learning course fulfils such requirements. It is one of the most effective teaching strategies, because it uses only those teaching methods which are suited to the needs of the learner. As a result, they have positive effect on the learner's motivation.

E-learning is an innovative method of knowledge because the methods of solidifying the learning material are based on the profound research on the human brain, conducted in order to examine how it is constructed and how it functions.

Numerous experiments clearly prove the existence of potential, though still not discovered, possibilities of memory processes. Nowadays, these possibilities can be enhanced via various mnemonic techniques [2]. Among them, regular repetitions seem to be the most crucial, because they facilitate effective knowledge acquirement, selection of information and its further use. Model of the functioning of the e-learning system is presented in Fig. 1.

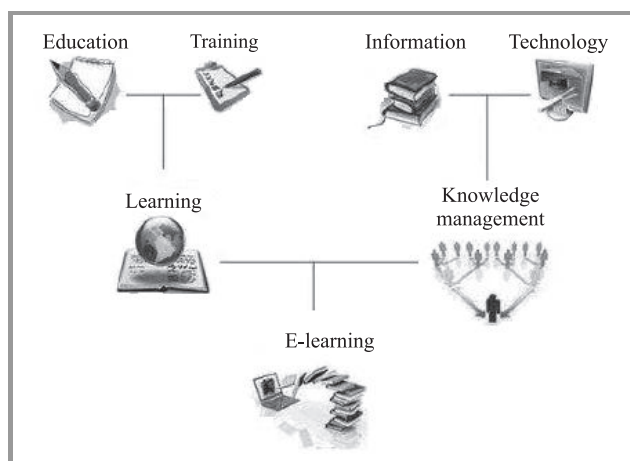


Fig. 1. Model of the functioning of the e-learning.

The suggested application of learning orthography of the Polish language refers to the above-mentioned recommendations, emphasizing above all the interactivity and virtuality of the learning reality.

2. Methods of Memorizing the Learning Material through E-learning Courses

The standards of an e-learning course (regarding the design of the learning material) concern establishing and describing training aims, defining the conditions of the course distribution, and using the prototypes of the projected system. First of all, the learning content should serve principally the educational needs. Gaining new competencies and skills is much easier for a user if the content underwent hierarchization and the legibility and cohesion of the transfer was strengthened. Thus, we should take into consideration the possible equipment limitations of the users and thought

out the layout of the course, providing cohesive navigation. Portioning the material is also a significant element, because we better learn smaller fragments than big chunks. For a learning process to be effective, the material which is supposed to be memorized should be divided into smaller fragments, i.e., lesson units. A kind and method of division also influences the quality of the learning process [1].

It is proved, that breaks have a beneficial effect on the process of learning. We remember better the things we read at the beginning and at the end, worse the middle part of the material. So, thanks to the breaks we have more beginnings and endings.

Last but not least, to learn better one should not forget about the crucial role of the memory, which is dependant on the metabolic processes the brain is involved in. For instance, eating a heavy meal causes temporary sluggishness and low responsiveness. Avoiding heavy meals and sugars before a bigger mental effort is also advisable, because it increases the level of insulin in blood and thus affects the functioning of the brain. However, it is important not to starve either, because the brain needs fuel to operate.

3. Methods of Planning Repetitions

An important element of the learning process is repetition. Repetitions are very important because learning means creating new tracks in one's mind. The more often they are used, the better are shaped connections between neurons. Revising the material is a necessity so it needs to be carefully planned. Thanks to repetitions, knowledge is systematically solidified and it stays longer in memory. The optimum time after which a material should be revised varies for different people, it depends on individual predispositions of a learner. To be able to remember the memorized material for a longer time, repetitions should be organized not accidentally but with suitable breaks [2]. Consequent revisions can be planned in the following way:

- after about ten minutes from studying,
- the same day before going to sleep,
- in the morning of the next day,
- after a week,
- after a month,
- right before using the gained knowledge, e.g., before the exam.

3.1. Determining the Best Possible Time of Revision

The optimal time for revision is different for various learners. I will concern the e-learning system intended to teach the orthography. I used the neural network and forgetting curve to set the optimal time for the revision.

German psychologist Hermann von Ebbinghaus drew the forgetting curve (also known as the Ebbinghaus curve) which stems from his research on human memory. It reflects the observed regularities in the process of learning

and forgetting, namely, it illustrates the relationship between the amount of acquired information and the time which passed since the moment of learning. At the very beginning the curve is falling rapidly but then it turn almost flat. The forgetting curve is presented in Fig. 2.

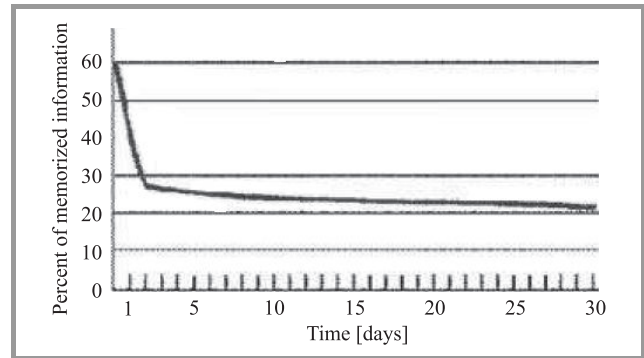


Fig. 2. The forgetting curve.

Once the learning is finished the amount of memorized information decreases rapidly. Half of the material is forgotten in an hour. Two days later the forgetting process is remarkably less rapid. Thanks to the revision of the acquired material the pace of forgetting is slower and slower. The Ebbinghaus curve can be approximately projected by means of the following functions:

- Exponential function:

$$m = (a - c)e^{-bt} + c, \tag{1}$$

where: m stands for the amount of memorized information, b for the coefficient of forgetting, a for the coefficient of memorizing, c for the asymptote, t for the time.

- Power function:

$$m = g(1 + bt)^{-i}, \tag{2}$$

where: m stands for the amount of memorized information, g for the level of the long-term memory, t for the time, i for the coefficient of forgetting.

The forgetting curves projected when the learning material is revised is presented in Fig. 3

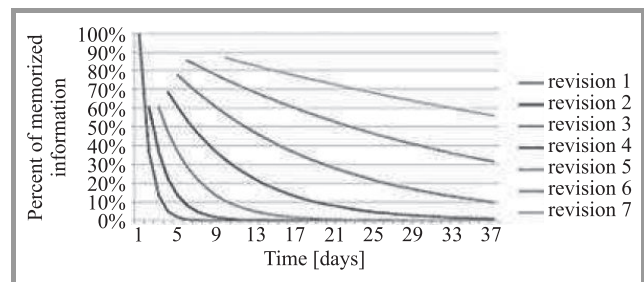


Fig. 3. Forgetting curves projected when the learning material is revised.

According to the forgetting curve, ten minutes after the termination of the learning process a man holds on 90% of the information he has gained. If we repeat that information we will enhance the relative power of memorizing and thus lengthen the period when it can't be forgotten.

The system uses the projection of the forgetting curve in the power form, namely in the form of the following equation:

$$R = e^{-\frac{t}{s}}, \tag{3}$$

where: R stands for the amount of easily-recalled information, t for the number of days measured from the revision, s for the relative power of the memory.

Now, what we seek is the proper value of the time between two revisions. Hence, we transform the Eq. (3) to the form:

$$t = -s \log R. \tag{4}$$

For the sake of convenience we assumed that $R = 70\%$. It is the threshold value for the system, which means that the revision takes place whenever the level the memorized information reaches 70%. The chart in Fig. 2 illustrates how the revisions affect the shape of the curve. We should notice that the time of the revision is calculated by means of the universal methods. Hence, the system of revisions should be deprived of any personalization.

3.2. Determining the Following Revision by Means of the Neural Network

The concept of the artificial neural network is derived from the research on human mind and the interrelationship between the artificial neurons. Nowadays, artificial neurons are interconnected variously, either in the software or within the integrated circuits. The e-learning system is grounded on the multilayer perceptron neural network [3], [4].

The provided network is taught by means of the method of the backward propagation of the errors (abbr. to back propagation), which belongs to supervised methods. It rests on the providing the network being learnt with some raw data and the expected output data. The network learns correcting the neural weights: the final error committed by the network should be less severe than the error set at the beginning. The name "backward propagation" is derived from the way the errors are computed in each particular layer of the network. It begins with the computation in the output layer by comparing the received and expected data. Then the errors for the preceding layer are computed (as the functions of errors of the preceding layer) and so on, up to the input layer. For better effect, the number of learning cycles is fixed. It enables the value of the final error to be decreased [5]–[7].

The artificial neural network was taught by means of the experimental set including the values of data for each of the 4 inputs and expected output values. The student is provided with the pre-taught network which enables him to use the system. Then the network is adjusted to the way the student's memory functions. The adjusting process has global character because it appertains to the entire

set of questions related to the particular orthographic rule (and not to a single question). The network is taught again whenever:

- the student was graded very well; it could be up to 5th revision and there was more than 10 days between revisions,
- the student was graded very well; it was more than 10th revision and more than 200 days between revisions.

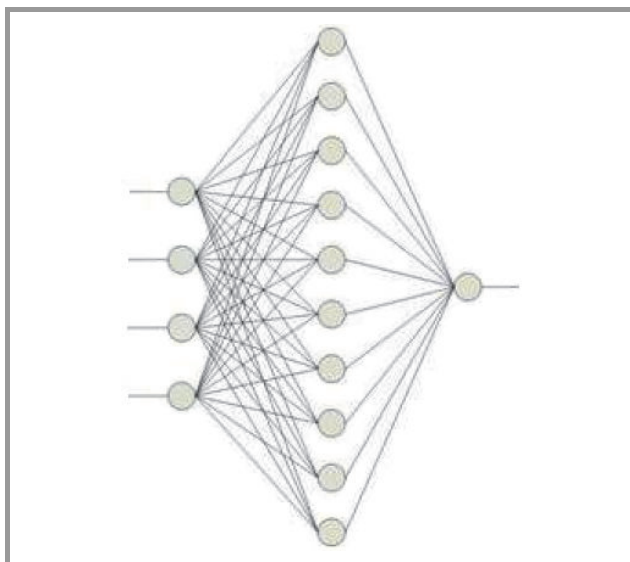


Fig. 4. Neural network provided for the purpose of the e-learning system.

The network is protected from over-learning by the threshold value which sets the maximal number of teaching cycles, e.g., 10000. Neural network provided for the purpose of the e-learning system is presented in Fig. 4.

4. E-learning Course to Learn Polish Spelling

The survey concerning the use of IT in teaching the humanities in primary schools conducted in 2005 shows that nowadays e-learning is a very important aspect of teaching. The results indicate that multimedia programs supporting traditional teaching are becoming more and more popular – they facilitate searching out information and broadening knowledge. They influence the effectiveness of teaching, because pupils absorb information faster, remember more, develop new skills – self-reliance, ability to draw conclusions, logical thinking, cross-domain knowledge and expertise, and perceptiveness [8].

The results show positive personality traits observed among students who use multimedia programs. Perceptiveness, ability to search out the most important information and drawing logical conclusions are most often observed among people trained by e-learning methods. The results are op-

timistic and encourage using e-learning courses. But only conscious and thought-out methods, adequate to student's needs, age and capabilities, are genuinely effective.

The studies also point to the computerization of the humanities curriculum. Teaching grammar and spelling of Polish is difficult and time consuming, and therefore the most popular programs are those which support teaching these branches.

Among many offers available, most are programs for students who already have some knowledge and are willing to organize and systematize it. The most frequent are collections of dictations read by native speakers. For each text a detailed description and proposed exercises are available in order to verify the knowledge and improve the skills. Theoretical issues are grouped into thematic blocks concerning both punctuation and spelling. One can also create their own exercises or add new dictations, as well as use the built-in spelling dictionary.

Another advantage is the possibility to customize the interface (there are several options to choose from) to user preferences and graphic statistics editor which shows educational progress of individual users in the form of graphs and fractions. It is an interesting option for students who already have established knowledge of orthography. The program also allows monitoring the work progress. Half of the surveyed teachers use this type of support in teaching spelling of the Polish language in primary schools.

An equally popular form of learning spelling are adventure games designed for younger students who, along with virtual characters, solve spelling puzzles and reach subsequent levels. As they are attractive, they facilitate learning the principles and rules of spelling and they support reading comprehension. A Polish language teacher may therefore use a wide range of multimedia programs to support conventional teaching. However, the offers available are mainly educational games and interactive tests. A student takes on a role, e.g., of a traveler or a detective, and, on the basis of the existing knowledge, they overcome obstacles, gaining further degrees of initiation until they solve the puzzle. To take full advantage of this training material, the gained and established knowledge is required. Moreover, the correctness of the tasks given to students is verified, but unexplained. There is no feedback with the extensive commentary, as well as no virtual teacher/mentor to support the trainee's activities.

A proper selection of an educational program stimulates students, even the weaker ones. Familiar topics, attractive graphics and sounds, interesting and diverse in terms of difficulty tasks with elements of fun, different forms of rewards for good work are all able to attract students' attention for much longer than other teaching aids.

The solution which offers both an attractive layout and an abundance of learning content is the e-learning course. Despite the growing interest and demand for this form of training, e-learning courses for teaching spelling to students in grades IV–VI are currently not included in the primary schools' offer.

The proposed e-learning system is based on the knowledge of Polish spelling. Exercises, lessons and tests – all training material included in the course is developed in accordance with the principles and rules of spelling. It offers substantial support to students – a set of principles and rules of spelling tailored to their intellectual and cognitive capabilities and a wide base of exercises and tests that can be continuously expanded and modified. The teacher can also define lesson units by selecting predefined exercises that students from given classes will implement in a given class. The proposed exercises and lessons take into account the individual pace of students' work and allow the teacher to monitor the results.

The students have an opportunity to get acquainted with theoretical knowledge concerning the principles and spelling rules of the Polish language and to perform a set of exercises whenever and wherever they want. They have the possibility to verify their answers, check the mistakes and re-do the exercise.

The e-learning support of teaching spelling may be used in primary schools which use electronic forms of learning in classes. It is an easily adaptable application – it can be extended by additional modules compliant with the requirements of the educational system.

It suits both motivational expectations of students, who nowadays prefer remote teaching, and contemporary tendencies in the psychology of learning, which emphasizes active forms of teaching through playing. It also allows the learner to extract the feedback and correct their errors, which increases the motivation to learn. One should note the possibility of integrating teaching of spelling with teaching Polish grammar, phraseology and punctuation. The designed e-learning system is a methodological proposal for ill students or those from integrated classes.

The system is divided into two modules: teacher and student panel – depending on the user's authorization.

4.1. Teacher Panel

After logging in, the teacher is able to use the panel, which is divided into four parts:

- Exercises module lets the teacher define, view and edit tasks that students should do on their own.
- Students module allows users to define the roles of users allowed to use the system.
- Lesson module allows the teacher to suggest any set of exercises on spelling rules that the student should do within the teaching unit. Exercises constituting a lesson unit can be freely selected from a pool of available exercises. If the teacher wants to use the new set of exercises, they must enter them into the database earlier using the tab Exercises – Add new.
- Test module allows defining, viewing and editing multiple choice tests which check the student's acquired knowledge of the spelling of the Polish lan-

guage. The tests allow the teacher to assess the effectiveness of the course and the personal attributes of each student. The applied data validation prevents them from choosing more than one answer. Scoring is distributed evenly – each question scores one point. The maximum number of points one can get for all the correct answers is 24. The system informs the student about the number of points obtained and the mark given for the test (numerical and descriptive suggesting a direction for further work in the event of a negative evaluation, or encouragement to achieve even better results).

The teacher has the possibility to view individual students' test results, they can also print them in the form of reports. Test results apply to an individual student attending given class. All tasks solved in a given test are displayed, as well as the student's answers and the correct answers. A personal report gives the number of correct answers and the mark suggested. The obtained results allow for a credible assessment of the student's skills and competencies.

4.2. Student Panel

After logging in the student is able to use the student's control panel, which is divided into three parts:

- Exercises module allows getting acquainted with theoretical knowledge on spelling principles and rules of the Polish language and their practical application – the implementation of a set of exercises illustrating the correct spelling within a particular rule. The student checks the answers and verifies the mistakes, e.g., using a spelling dictionary.
- Lessons module allows the student to choose a set of exercises, done within the lesson unit. Exercises, suggested by the teacher, match the spelling rule/rules.
- Test module includes multiple choice tests with assessment that the student does independently. After selecting the type of the test the first question is displayed. After choosing the answer, the next question is shown.

The student has an opportunity to check the correct solution of the test, but only after its completion. On the monitor there is a report displayed, informing the student, which answer was chosen and giving the correct answer. At the end of the report there is a summary – the number of correct answers and the proposed mark.

Thanks to the data base of the questions, the system is able to organize repetitions. Repetitions involve showing consequent questions by the system on the main panel of the application, to which the learner answers. The answer is then verified by comparing it with the correct one. The system enables also course and user's accounts administration, their rights to get to specific functions and platform's resources. It allows adding a new course or adding

new information to the existing ones. The important element is communication between the individual members of the course and the teacher in a synchronous way (chat) and asynchronous one (forum, email) and creating virtual groups of members and teachers. The valuable source of information about the effectiveness of the proposed course is the ability to examine the activity of the learners, surveying the members and teachers and checking the learning progress.

5. The Results of the Research

The e-learning system was tested on two groups of 15 students. Each of them had to perform the same task: get acquainted with the theoretical material concerning Polish spelling and do a set of several exercises testing in practice the acquired knowledge. At the end the students had to do a final test summarizing their skills in the proper use of the spelling of the Polish language.

The first group implemented the program of the experiment based on traditional methods of teaching, i.e., learning the rules and on their basis doing exercises given by the teacher, dictations from the whole of the material, writing down difficult words. The students were passive participants of the course; they received information and executed commands. The second group used the proposed e-learning system supporting learning spelling. The students learned new rules and did the exercises on the spot. They immediately got feedback on their mistakes and successes. Error correction resulted in faster and more efficient mastery of the theoretical material, and thus better results in the performed exercises and tests.

The results clearly show that active learning, engaging students in the process of learning new information, brings much better results than traditional methods. The students who use e-learning system were more likely to learn, showed greater initiative and self-discipline throughout the entire educational process. The effectiveness of assimilating knowledge of the Polish spelling in the second group was nearly 15% higher than in the first group.

Multimedia education affects students' senses to a greater extent than conventional teaching. Thanks to that, the effectiveness of learning has increased by as much as 15%, understanding of the subject by 46% and the range of absorbed knowledge was higher by 35%. In addition, e-learning makes it possible to reduce the difficulties and ambiguities in the implementation of learning – in this case by 28% and time saving of 40% while increasing the pace of work by 25%. Using these programs, however, requires a teacher care. Student's independence should be supported by the teacher's experience and knowledge.

Tests also were conducted in two 15-person groups. Students from the first group were provided with e-learning course without the support of scheduling the term of revision, whereas the second group of students were provided with the system where the optimal time of revision was scheduled by the neural network built-in the system.

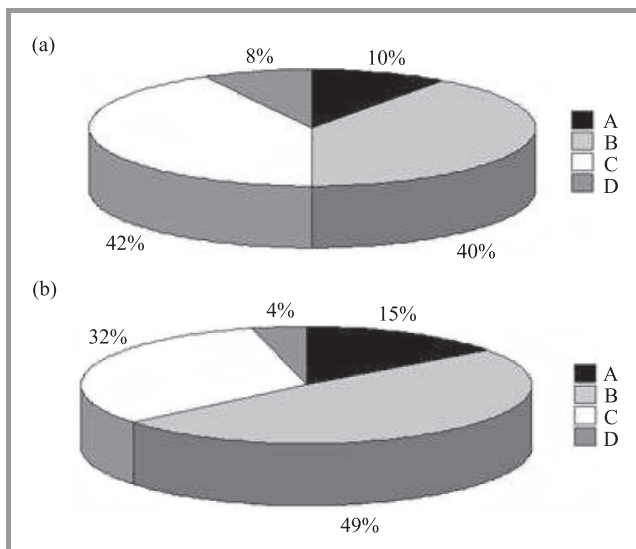


Fig. 5. Results of the research for (a) – first group and (b) second group. Evaluation used in the experiment: A – very good, B – good, C – fair, D – failed.

Among students using the system with neural network the efficiency of memorizing the training material has increased by 15%. Experiment results have been shown in the diagrams in Fig. 5.

6. Summary

The e-learning system enhancing the process of learning the orthography in school has also the additional module. It manages the gained knowledge, enabling the revisions to be planned. Similar systems lead the education to its future.

So far, one could set the conditions under which the time of revision may come, but they apply to every orthographic rule. Perhaps we should enable the users to set a distinct conditions for each orthographic issue. Transferring the coefficients of the artificial neural network, so that they accommodate to the conditions of the particular rule, would make the following revisions for the particular sets of questions more correct. The questions concerning the particular orthographic rules could be more or less difficult, what would affect the process of memorizing the informa-

tion. Apart from that, the system could be expanded with the statistics providing the fixed dates and results of the revisions. Owing to them the student would be aware of his current state of knowledge and of particular difficulties. He would know if his learning policy is efficient or needs to be changed.

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