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Message from the Editor-in-Chief

TOJSAT welcomes you.

I am very pleased to publish v10i2, 2020 issue. As an editor-in-chief of The Online Journal of Science & Technology, this issue is the success of the reviewers, editorial board and the researchers. In this respect, I would like to thank to all reviewers, researchers and the editorial board.

This issue covers different research scopes, approaches which subjects about new developments in science and technology by valuable researchers. The editorial team will be pleased to share various researches with this issue as it is the miracle of our journal.

TOJSAT, will organize ISTEC-2020 (International Science & Technology Conference) (www.iste-c.net) between September 2-4, 2020 at Cyprus International University.

Call for Papers

TOJSAT invites article contributions. Submitted articles should be about all aspects of science & technology.

The articles should be original, unpublished, and not in consideration for publication elsewhere at the time of submission to TOJSAT.

For any suggestions and comments on the international online journal TOJSAT, please do not hesitate to fill out the comments & suggestion form.

July 01, 2020

Editor-in-Chief
Prof. Dr. Aytekin İŞMAN
Sakarya University

Message from the Editor

Dear Tojsat Readers,

We have been publishing the Online Journal of Science and Technology since 2011.. Audiences andreaders of the journal is widening throughout the World and increasing especially after the conference series of Science and Technology. Tojsat journal is now indexed with Doaj, Dergipark, Cite Factor and Index Copernicus, Google Schoolar and will be cited by Scopus index soon.

The journal favours papers addressed to inter-disciplinary and multi-diciplinary articles shown in the section of scopes. In this issue of on line journal, selected papers such as use of Molten Salt Method in the Synthesis of Metal Hydride Electrode Materials, The reflection of Urban Poverty on Child Poverty, The Neutron Macroscopic Cross Sections Calculation of Some Minerals By Using Fluka Monte Carlo Method, etc. will be published.

I will thank to the readers for their supports by sending their valuable scientific works to publish in this journal.

July 01, 2020
Assoc. Prof.Dr. Tolgay KARANFİLLER
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Table of Contents

DESIGN OF A TEACHING-LEARNING SEQUENCE TO FACILITATE TRANSITION BETWEEN QUALITATIVE AND QUANTITATIVE REASONING ABOUT KINEMATICS PHENOMENA

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Abstract : Science experiments offered to the pupils in physics classrooms generally do not take into account their alternative conceptions in relation to physical phenomena so that they can encounter difficulties in identifying pertinent factors and expressing it in the form of quantitative equations (Ploetzner & Spada, 1998). Our research aims to specify the transition process between an understanding of an intuitive nature of the properties of phenomena, centered on the qualitative reasoning, and a more definite understanding, centered on the quantitative reasoning such as it is used in problem solving. To favour the understanding of physical phenomena, qualitative as well as quantitative reasoning must be mobilized and used in pedagogic contexts allowing exchanges between the pupils and favouring interaction with phenomena (Trudel, 2005). When combined with activities of exploration of physical phenomena, the resulting approach used feedbacks from the results of manipulations to limit the number of issued hypotheses, which is a prerequisite to their practical verification (Gunstone & Mitchell, 1998; Trudel, 2005). Moreover, the use of software, making easier the collection of data and their organization in form of tables and graphs, allowed the pupils to test their hypotheses much faster than with the traditional laboratory equipment so that pupils can change progressively the parameters of physical situations studied to explore relations between the physical variables (Riopel, 2005). As a conclusion, we draw the limits of the study and offer suggestions to teachers to improve the integration of qualitative and quantitative reasoning in the physics classrooms.

Keywords : Computer-assisted laboratory, kinematic, qualitative reasoning, model, understanding, problem-solving

Introduction

In response to what some have called traditional science teaching, consisting of lectures, exercises, and laboratories, Anderson (2002) recommends that pupils take a more active role in developing their knowledge under the supervision of the teacher. In this approach, called guided discovery, learning results from activities of testing pupils' ideas about the phenomena of their environment. By studying a phenomenon, the pupil is led to identify its properties, propose hypotheses to explain them and develop an experimental protocol to verify them. In doing so, he develops a better understanding of the scientific concepts and methods used by scientists to study the natural world (Llelewyn 2002, Someren & Tabbers 1998).

According to de Jong and van Jooligen (1998), pupils have difficulties in the various phases of the experimental process: hypothesis generation, experimental protocol design, data interpretation and the regulation of the experiment itself. Since these phases, although distinct, are interrelated, these difficulties can only be solved by teaching methods that take into account the cyclical and iterative nature of this approach (Acher & al., 2007, Llelewyn, 2002, Toplis, 2007). Thus, the formulation of hypotheses depends on the interaction between, on the one hand, the pupil's ideas about the phenomena studied and, on the other hand, the characteristics of the phenomena themselves (Trudel, 2005). Among the physical phenomena studied in high school, the learning of motion phenomena, or kinematics, is important for pupils for several reasons: 1) mastery of kinematic concepts is a prerequisite for learning subsequent physical concepts; 2) in kinematics, the pupil learns new methods, such as the construction of Cartesian graphs, the systematic measurement and collection of data, problem solving, etc., which will be useful in more advanced physics courses.

However, if there is one area that causes many difficulties for pupils, it is kinematics, defined as the study of the motion of objects without worrying about its causes (Champagne, Gunstone & Klopfer, 1985, Arons, 1990). There are several reasons advanced by researchers. First, before entering in physics classes, pupils have a wealth of experience about the properties of the motion acquired in their interactions with everyday events (Forbus and Gentner, 1986). This experience enabled them to construct a set of schemas to interpret the phenomena of motion (Champagne, Gunstone & Klopfer, 1985, Forbus & Gentner, 1986).

These schemas are perfectly adapted to the tasks of everyday life: riding a bicycle, catching an object, etc. On the other hand, these patterns differ markedly from scientific concepts. In some cases, these patterns may even interfere with learning, especially if the teacher ignores them. In this case, there is a great danger that pupils will distinguish school knowledge, which functions at school (for example, in the laboratory), from everyday knowledge, which enables them to react effectively to everyday events (Legendre, 1994).

A second reason for the difficulty of kinematics is the way it is taught in introductory courses in physics. Indeed, kinematics are often approached using a mathematization to which the pupils are not accustomed (Arons, 1990). For example, a common pedagogical procedure involves bringing pupils, at the beginning of the kinematics study, to the laboratory where they measure different properties of the motion they then carry on graphs. Back in class, they analyze the results obtained and perform calculations using formulas to obtain the values of speed and acceleration. However, it appears that pupils perform these various operations without a real understanding of what they do (Trempe, 1989, De Vecchi, 2006).

Finally, pupils' kinematic difficulties may also come from the way they process information. For example, pupils are inclined to make global judgments of comparison without taking into account the initial or final conditions of the motion studied. (Trowbridge, 1979, Trowbridge & McDermott, 1980, 1981, Feltovich al., 1993, Marshall & Carrejo, 2008). Often, even the concepts of speed and acceleration coincide with each other (Dekkers, 1997). These difficulties may prevent pupils from establishing appropriate links between concepts and, as a result, make it difficult for them to understand these (Stavy & Tirosh, 2000). These concepts may be inadequate and differ from the laws that form the conceptual framework of physics (Ploetzner & Spada, 1998).

To facilitate pupils' understanding, it is preferable that the concepts be presented concretely, in the form of physical models (Marshall & Carrejo, 2008). A physical model describes the simplifications, the links, the constraints and the internal structures of the studied phenomena (Greca & Moreira, 2002, Halloun, 1996). By studying various phenomena grouped in the form of physical models, the pupil comes to develop an internal representation of this situation, consisting of the elements chosen to interpret it and the perceived or imagined relationships between these elements (Acher & al., 2007; Greca & Moreira 2002, Halloun 2004). The result of this modeling of phenomena, in which the pupil identifies the different components of the situation studied as well as their relationships, is systematized in the form of better structured and more adequate cognitive schemas to perform certain scientific functions, for example to explain a more varied range of phenomena (Anderson & Roth, 1989, Halloun, 1996, Marshall & Carrejo, 2008).

To make it easier for the pupil to handle the experimental process required for these modeling activities, it is preferable to introduce the study of phenomena in a qualitative form for several reasons: 1) qualitative reasoning is familiar to pupils because it is used in everyday life (Forbus & Gentner 1986, Legendre 2002); 2) qualitative reasoning allows pupils to better discern the links between concepts because they are not distracted by the need for extensive mathematization (Champagne & al., 1985); 3) qualitative reasoning facilitates the recognition of the limits of the solution found and the constraints of the physical situation (Mualem & Eylon 2007, Goffard 1992).

On the other hand, there are limits to qualitative reasoning: 1) in several situations, it remains indeterminate, since it is not possible to predict the outcome (Crepault, 1989, Parsons, 2001) ; 2) it does not discern the relationships between several variables because it remains limited to the comparison of changes between pairs of variables (Someren & Tabbers, 1998); 3) The units of the variables are not taken into account because these units are determined by the measurement process that refers to the existence of an operational definition of the concept (Arons, 1990, Mäntylä & Koponen, 2007).

On the other hand, quantitative reasoning makes it possible to specify the functional relations that the variables relevant to a phenomenon have between them. In addition, this reasoning makes it possible to consider the interactions between several variables. Finally, the formulation of a rule in the form of an equation makes it possible to explain the properties of a phenomenon in the form of a system of relations of great generality (Mäntilä & Koponen, 2007, Safayeni & al., 2005).

Nevertheless, this type of reasoning is unfamiliar to the pupil so that he may have difficulty connecting various quantities together. Indeed, in order to solve problems requiring quantitative reasoning, pupils often resort to superficial methods of solving the problem of choosing a procedure on the basis of indices provided in the statement (Goffard 1992, Mestre & al., 1993). To overcome these shortcomings, the combination of qualitative and quantitative reasoning in a problem-solving strategy allows pupils to better understand physical concepts and improve their problem-solving skills (Gaigher & al., 2007).

Nevertheless, if this combination seems to improve physics learning, the way how to coordinate them still needs to be determined. To this end, different approaches have been suggested (Parsons, 2001). Among these, two approaches have been used in physics teaching. A first approach is to apply them one after the other. In this approach, qualitative reasoning favors the expression of a small group of plausible hypotheses about the properties of a phenomenon from a set of possible hypotheses (Parsons, 2001). Subsequently, the formulation of these hypotheses in a quantitative form makes it possible to specify among this small group the few hypotheses to be verified (Someren & Tabbers, 1998). The second approach, which integrates qualitative and quantitative reasoning, begins with the qualitative description of the properties of the phenomena and their classification in the form of relationships. The experiments are designed to transform the identified qualities into measurable quantities (allowing, for example, the operational definition of temperature) and qualitative relationships into quantitative laws (Koponen & Mäntylä, 2006). Nevertheless, these two approaches do not take into account alternative conceptions that pupils may have about the phenomenon being studied so that pupils may find it difficult to identify the relevant factors and to express them in a form that facilitates the quantitative formulation by pupils (Ploetzner & Spada, 1998).

To establish links between understanding and reasoning, both qualitative and quantitative, these processes must be mobilized and used in pedagogical contexts that allow exchanges between pupils and favor interaction with phenomena (Trudel, 2005). In this respect, it seems that pupils, in the Someren and Tabbers (1998) study, worked alone. Working in groups, especially when sharing information and exchanging points of view, such as in a small group discussion, allows pupils to access many sources of information and information. to open up to a diversity of points of view, which can favor the formulation of hypotheses (Trudel & Métioui, 2008). When combined with the exploration of phenomena, this approach provides feedback from the results of manipulations that limit the number of assumptions made, which is a prerequisite for the practical verification of these (Gunstone & Mitchell, 1998 Trudel, 2005).

However, it seems that, with regard to the study of phenomena, pupils have little opportunity to propose their own hypotheses in science laboratories (Nonon & Métioui, 2003, Trudel & Métioui, 2008). In addition, a study of the protocols proposed by the laboratory manuals in Quebec shows that pupils are seldom offered the opportunity to engage in an authentic research approach, the steps proposed by these manuals focusing on procedures for data collection and analysis (Métioui & Trudel, 2007). This high degree of structure of the tasks proposed in the laboratory can be explained in different ways: 1) a certain "pragmatic" conception of science leads teachers to prefer laboratories to guide pupils to the correct answer using proven methods and the pupils to be satisfied with having obtained the desired answer (Legendre, 1994, Toplis, 2007); 2) autonomous research would require mastery of several scientific skills, including identification of variables, quantification, coordination of facts and assumptions, etc. (de Jong & van Jooligen, 1998); 3) time and equipment constraints do not permit the repetition and modification of experiments (Toplis, 2007); 4) experience is seen more as a means of testing a hypothesis rather than discovering it (Koponen & Mäntylä, 2006).

To overcome these drawbacks and thus facilitate a more authentic investigation of scientific phenomena, the use of technology would facilitate and increase both the quantity and the quality of the data collected on the phenomena while supporting the pupil in his approach (Jonassen, Strobel & Gottdenker 2005, Hofstein & Lunetta 2004).

Such an approach, called a computer-assisted laboratory, has several advantages: 1) it allows the pupil to focus on the generation of hypotheses and the interpretation of results, two skills that are not well developed in traditional laboratories (Gianono, 2008); 2) it allows the pupil to quickly generate and verify several hypotheses, by facilitating in the latter the strategies of variation of parameters necessary to formulate hypotheses about the properties of phenomena (Riopel, 2005); 3) in physical situations where it is necessary to revisit the results of an experiment to verify its quality or possibly to modify the original hypothesis, computer-assisted experimentation may allow the traditional laboratory's approach to become iterative despite the constraints of the school environment. Indeed, it is often necessary for pupils to look back at the results of an experiment to study the causes of the gap between their ideas and the results obtained, thus promoting conceptual change in science (Trudel, 2005).

In light of the above, a learning approach aimed at facilitating the transition from qualitative reasoning to the discovery of quantitative laws should include provisions to promote the expression and comparison of pupils' ideas with each other (eg small groups) and provide pupils with the opportunity to quickly and easily test their ideas using experiments supported by data collection and analysis software (Riopel, 2005, Trudel, Parent & Métioui, 1989). The iterative nature of this approach, which mobilizes both qualitative and quantitative reasoning, should enable pupils to gradually build a scientific model of observed phenomena (Acher & al., 2007, Schwarz & White, 2007).

Our research objective is therefore to develop a learning approach to facilitate the induction of quantitative rules on motion through the prior use by pupils of qualitative reasoning in a discussion among pupils about the kinematic phenomena studied in the framework of a computer-assisted experimentation.

Design of The Teaching-Learning Sequence

In order to study the transition (or coordination) between qualitative and quantitative reasoning, we need to design a learning process that can produce the desired changes (Siegler, 2006). To this end, we have designed a scenario of the activities as described in the previous section. This scenario specifies the different pathways that pupils can take to develop a better understanding by taking into account the particular difficulties they may encounter in their learning. This scenario includes the goals of the activities, the structure of the content of the field studied, the pathways followed by the pupils to reach their goals, taking into account the misconceptions they harbor and the activities offered to the pupils. The purpose of the activities is to help pupils develop a better understanding of kinematic concepts and problem-solving skills through an approach combining qualitative and quantitative reasoning about the properties of motion phenomena. The suggested approach aims to help pupils modify their schemas in stages so that they move progressively closer to kinematic concepts.

To represent the kinematic phenomena, we organized them into physical models. In kinematics, there are three models (Halloun, 2004): the constant speed motion in a straight line, the uniformly accelerated motion and the mixed motion that combines the first two. These models assisted us in designing specific activities to help pupils understand the different aspects of the motion. To facilitate the modeling of kinematic phenomena by pupils, we must determine the different ways pupils understand motion and consequently the different routes they can take in their learning.

To this end, we have designed networks of understanding the concepts of kinematics. These networks of understanding consist of two types of information: 1) the main concepts of kinematics, such as speed or acceleration, and their interrelationships; 2) indications of pupils' misunderstanding of these concepts (Klir, 2001, Trudel, Parent & Métioui, 2009). Once the conceptual structure of the domain and the misunderstandings identified, we organized learning activities to support the different routes that pupils can take by developing a better understanding of the properties of the motion (Méheut & Psillos, 2004).

With regard to modeling of kinematic phenomena, we have designed activities to meet the characteristics of the different models previously described: uniform rectilinear motion, uniformly accelerated motion, and mixed motion. To allow pupils to work in small groups (about four pupils), we have designed an activity guide to guide the pupil's approach. The guide contains cases to study different aspects of motion grouped in the three kinematic models described above. Each case includes activities (questions, graphs to complete, etc.) that guide the process of modeling pupils. The modeling process is structured according to a POE task (Prediction> Observation> Explanation) (Gunstone & Mitchell, 1998).

Each POE task runs as follows. A physical situation, represented in concrete form by a physical set-up, is explained to the pupils in the guide. Questions associated with this case ask the pupil to predict what will happen if the experiment is done. They then write down their predictions in their notebook. Pupils in groups of four then assembled the set-up associated with this case according to the guide's instructions. They observe the properties of the targeted motion and write their observations in their notebook. They then try to explain the gap, if any, between their predictions and their observations. In doing so, they can modify the set-up to study other aspects of the motion or to check alternative hypotheses emitted during their exchanges.

The verification of pupils' hypotheses is done in small groups at the computer-assisted laboratory. First, the videos of the balls rolling on rails at different inclinations are captured with a digital camera in the video recording position. The contents of the sequences filmed by the camera are transferred to the computer and transformed into a video file by the Quick Time software. Once in this form, the image sequences can be viewed as in a movie. Having inserted these sequences of images in the REGAVI software, the pupil can use the mouse with a cursor to take measurements of the successive positions of the ball as a function of time. These measurements are immediately tabulated by the REGAVI software. In addition, this software contains features for choosing reference axes, tracking the motion of multiple objects at a time, and matching the position and time intervals in the video with the positions and times measured at the experiment itself. Subsequently, the data tables provided by the REGAVI software can be transferred to the REGRESSI analysis software for analysis. The latter software has features that allow the user to make different graphs of position, speed and acceleration as a function of time. In addition, the REGRESSI software facilitates the discovery of relationships between variables by providing means for comparing the fit of different curves (linear, quadratic, exponential, etc.) to the data obtained.

Unfolding of the activities

We have implemented various aspects of the approach described in the previous section in several classes of high school pupils and the training of future science teachers (Trudel, 2005, Trudel and Métioui, 2010). We were inspired by the logbook information from this research and the results of the analysis of pupil responses in the pupil handbook to specify, based on the characteristics of the samples, the progress of the proposed approach in the classroom (Altrichter & Hollly, 2005). For the sake of clarity, we have chosen the three most significant cases in our case among those constituting the proposed approach (Trudel, 2005).

First case
The first case submitted to pupils consists of a POE task (see Figure 1) shows an excerpt from the description of this case in the pupil's guide (Trudel, 2005):
"A ball is thrown on a horizontal rail. The gray circle indicates its initial position at launch. The circle with the symbol 1 inside indicates the position of the ball after 1 second.”

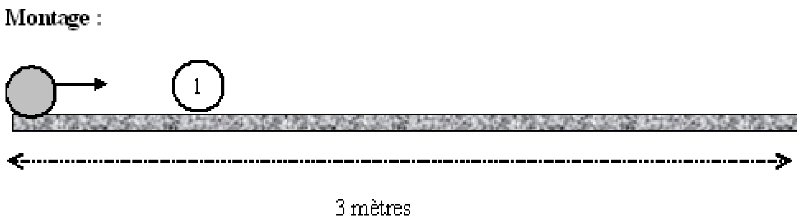

Figure 1 Motion of ball rolling on an horizontal track.

The POE task then consists in predicting what will be the successive positions of the ball every second, knowing the distance traveled in the first second. From these predictions, the teacher asks his pupils to draw a graph of what the position of the ball would be as a function of time. Indeed, it is important to encourage pupils to specify their prediction in a concrete way in order to compare it more easily to experimental results (White and Gunstone, 1992).

The teacher then proceeds to carry out the experiment. Then he asks them to explain any discrepancies, if any, between their predictions and their observations of the motion of the ball. It should be noted that the conceptions of pupils appeared similar from one group to another, and from one level of teaching to another (Trowbridge and McDermott, 1980, 1981):

1) The speed of the ball increases in the first part of the path, remains constant in the middle part, then slows down thereafter. It should be noted here that among the pupils who attribute an acceleration to the ball initially, some tend to confuse the initial time with that when the ball is set in motion by the experimenter.
2) The speed of the ball remains constant until the end, without noticeable slowdown. Some explain that the length of the rail is too short or that the slowdown is too slow to be detected.
3) The speed of the ball decreases gradually until it stops. Pupils who maintain this conception invoke friction as the cause of slowing down.

During classroom discussions, some pupils justified their choice of a conception based on visual evidences such as the ball appears or does not seem to slow down. At this stage, the pupils themselves propose to measure the velocities over intervals of time and distance chosen using stopwatch and meter. It is then possible to turn the discussion into experimentation in small groups. During the experiment, the sequences of the motion of the ball are collected using a digital camera and subsequently transferred to the REGAVI software and then to the REGRESSI software for measurement and analysis of the position and speed of the ball according to time.

The positions and times obtained are then tabulated and then plotted on position-time and speed-time graphs. In general, the computer system allows the pupil to measure the motions of the ball in the different successive time intervals and thus establish the constancy or not of the speed. In addition, the study of the shape of the curve of the position as a function of time makes it possible to compare it to the expectations of the pupils as to the form of this motion established in the prediction part of the POE task.

By providing various feedbacks, whether in pupils' exchanges or comparison of expectations with the results of experiments, such an approach is likely to facilitate a better understanding of kinematic concepts. Indeed, by comparing the shape of the two curves, pupils realize that, contrary to their expectations, the motion between successive time intervals is identical and that friction plays a negligible role. For pupils at higher levels, whose mathematics training is more advanced, it is possible with the REGRESSI software to compare the fit of the curve to different functions, whether they are linear, quadratic or other. So in this case, the curve obtained by the REGRESSI software is as follows:

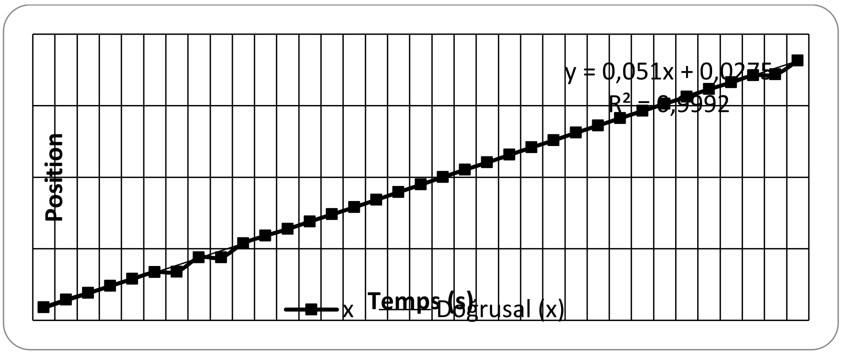

Figure 2 Position-time graph in case of uniform rectilinear motion

Second case

In addition, it is possible to consider complex physical situations (see Figure 3).

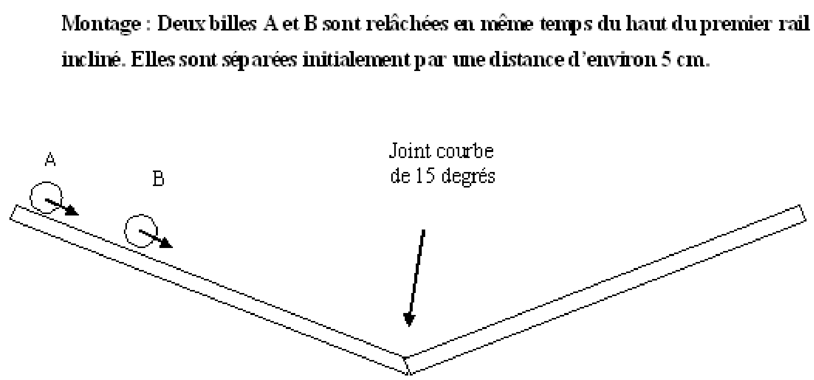

Figure 3 Motion of two balls separated by an initial distance down a system of two tracks making an angle

The teacher then asks the pupils if Ball A will eventually catch Ball B. In the Prediction section, he asks pupils to predict the respective positions of Balls A and B over time. In addition, he asks them from their predictions to plot the position-time and speed-time graphs of the two balls. In general, if the pupils have understood the previous cases concerning the acceleration of balls going down or down an inclined rail, they can study this situation and contribute to classroom exchanges. The debates that result from this scenario can be lively because it is a complex situation that includes an interesting issue, the prediction of the properties of a motion familiar to pupils.

In particular, the prediction of the position-time graph presents a particular difficulty because it consists of an upward parabola (acceleration) followed by a downward parabola (deceleration) (see Fig. 4). In this respect, the continuity of the speed, represented by the tangent to the position-time curve, allows that there is a point of inflexion between the two trajectory segments. As a result, this is a challenging situation for pupils of all levels. Nevertheless, the familiar nature of this motion situation makes it possible for everyone to participate in the discussion by making assumptions. In particular, some pupils may argue that the distance between the balls will not vary in the first segment, as the acceleration along the inclined plane is the same as well as their initial velocity (which is zero). Only when they go back does the motion become asymmetrical. Indeed, the ball A having descended the first part over a greater distance will start the second part with an initial speed greater than the ball B. In certain conditions which depend mainly on the initial distance between the two balls, the ball A will be able to catch ball B before it has reached the top of its trajectory.

This situation involves many concepts and we lack space to describe the different strategies adopted by the pupils. Even if it is possible by reasoning to provide convincing arguments in support of any of the ideas expressed by the pupils, the possibility of quickly taking data from the positions of the two marbles as well as amkinf readily position-time and speed-time graphs allow pupils to sort out various opinions and move toward a deeper understanding of the concepts involved.

Figure 4 shows that the position as a function of time corresponds to the juxtaposition of two parabolas, one upwardly downward and the other downward upward. As expected, the point of inflexion between the two parables is halfway.

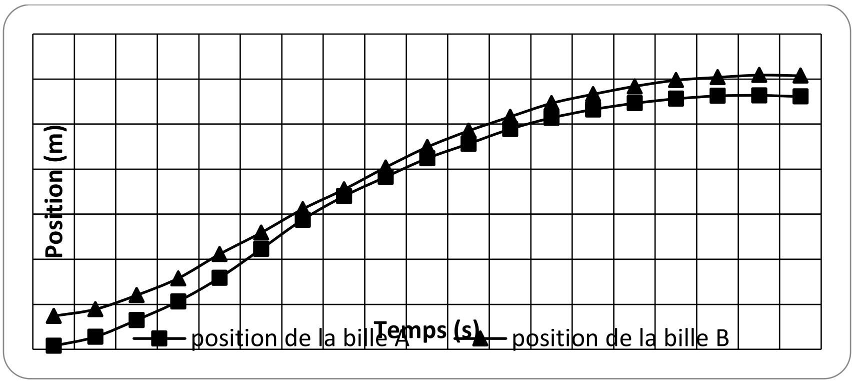

Figure 4 Position-time graph of the two balls in pursuit

Figure 5 below shows the speeds as a function of time of the balls A and B of this case of pursuit. It is noted in the first part of the path that the speeds of the two balls increase regularly with the same acceleration (the slopes of the lines are substantially the same). The two balls reach their maximum speed then decrease to zero. It is interesting to note that the final speed of the ball A is greater than the speed of the ball B (which could be predicted taking into account that the ball A is accelerated over a greater distance than the ball B). On the other hand, it is also curious to note that, in the second part of its trajectory, the speed of the ball A is lower than that of the ball B. This inversion takes place after the speeds of the balls A and B have become equal, at a time of about 7 seconds. A plausible explanation would be that the balls A and B then collided and some of the impact contributed to the decrease in the speed of the ball A.

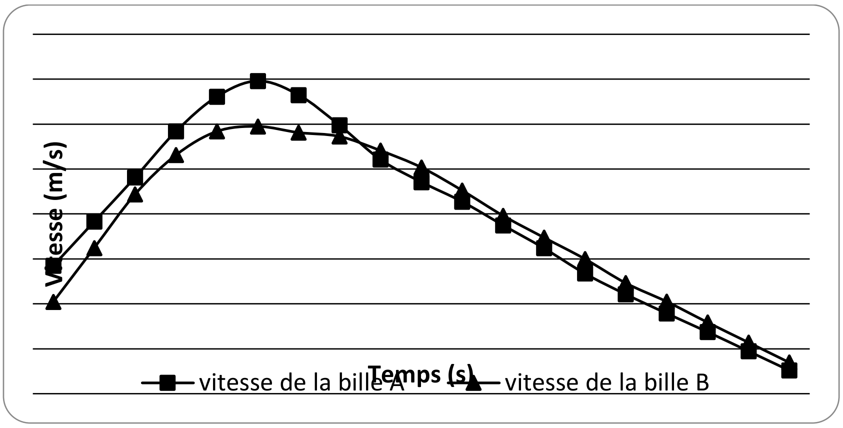

Figure 5 Speed-time graph of the two balls in pursuit

Third case

The third case is an example of a single ball whose segments of the trajectory have different motions (see Fig. 6):

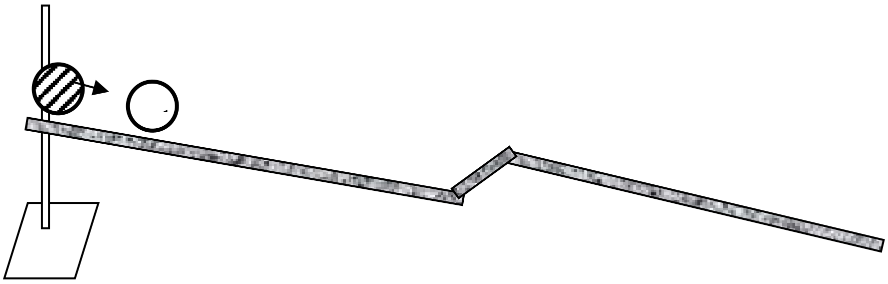

Figure 6 Ball rolling down an inclined track with a bump

In this case, the teacher asks the pupil to predict the different positions of the ball as a function of time. This case is an application of the concept of instantaneous speed and should be presented to pupils after they have studied the characteristics of accelerated motion and those of decelerated motion. To solve this problem, the pupil must juxtapose several parabolic motions in order to respect the continuity of the speed at the junction points. In Some pupils went so far as to invoke considerations of energy conservation. So, depending on where the ball is dropped, she might or might not have the energy to overcome the "bump".

The following graph shows the position of the ball as a function of time (see Fig. 7). We note that the first part of the motion is represented by a parabola directed upward (downhill) followed by a parabola section pointing downwards (raising of the hump) and finally again with a parabola facing upwards (descent again). It should be noted that the "mechanical" use of the regression could give us a line as a best curve, whereas by the discussion, most pupils can easily juxtapose the curves corresponding to each segment of the trajectory.

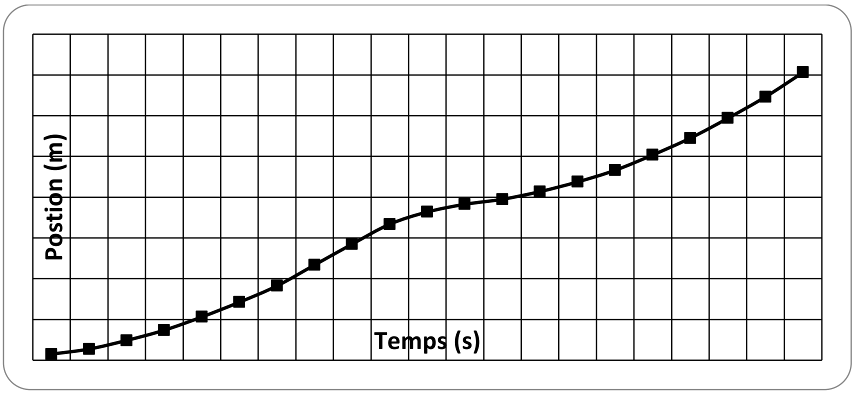

Figure 7 Position-time graph of the ball undergoing successive accelerated and decelerated motions

Discussion and Conclusion

The use of computers in the physics laboratory is revolutionizing the teaching of this discipline. Nevertheless, computer-assisted experimentation is too often devoted to the technical side of automated data acquisition and its organization in the form of tables and graphs. This emphasis on the technical accuracy of the measures, despite its rigor, may obscure the need for judgment.

It is one of the essential characteristics of common sense to be able to understand the physical phenomena that surround us without having to go through advanced mathematization, which is not very effective in solving everyday problems. Nevertheless, it is not a question of abandoning the mathematization of the properties of the phenomena but of approaching it when the essential elements of the problem have been understood by the pupils.

The approach presented here proposes to use the capacities of the computer so that the pupil can, from a representation of common sense, of qualitative nature, of the properties of the phenomena, to pass to a mathematical representation in the form of position-time and speed-time graphs. Our semi-quantitative approach allows, through reasoning, pupil-to-pupil exchanges and the use of various modes of representation, for high school pupils to study kinematic phenomena of a complex nature, previously reserved for postgraduate education, college and university in particular. These still embryonic results seem promising.

In particular, studies involving groups of pupils under controlled conditions, difficult to reproduce in the heat of the teacher's daily action, would make it possible to follow the progress of pupils when they make the transition between their common sense representations and scientific representations. To date, research in science didactics has studied pupils 'understanding of simple phenomena in which pupils' conceptions have mostly been acquired through the observation of everyday phenomena. However, studying pupils' alternative conceptions when they are experimenting with the properties of complex motion phenomena would allow us to better understand how these pupils relate the various kinematics concepts needed to solve them.

References

Acher, A., Arca, M., et Sanmarti, N. (2007). Modeling as a Teaching Learning Process for Understanding Materials : A case study in primary education. Science Education, publié en ligne au site www.interscience.wiley.com DOI 10.1002/sce.20196.

Altrichter, H. et Hollly, M.L. (2005) : "Research Diaries", In B. Somekh et C. Lewin (Eds.), *Research Methods in the Social Sciences*, chap. 2. Thousand Oaks (Californie) : Éditions SAGE.

Anderson, R. E. (2002). "Reforming science teaching: What research says about inquiry". Journal of Science Teacher Education, 13(1), 1-12.

Anderson, C. W., et Roth, K. J. (1989). "Teaching for meaningfull and self-regulated learning of science". Advances in Research on Teaching, 1, 265-309.

Arons, A. B. (1990). A guide to introductory physics teaching. Toronto: John Wiley & Sons.

Champagne, A. B., Gunstone, R. F. et Klopfer, L. E. (1985). "Instructional consequences of pupils' knowledge about physical phenomena". In L.T. West et A.L. Pines (Eds), Cognitive structures and conceptual change (pp. 61-89). Montréal: Academic Press.

Crépault, J. (1989) «Temps et raisonnement: Développement cognitif de l'enfant à l'adulte». Presses Universitaires de Lille, 558 p.

De Jong, T., et van Joolingen, R. (1998). "Scientific discovery learning with computer simulations of conceptual domains". Review of Educational Research, 68(2), 179-201.

Dekkers, P. J. J. M. (1997). "Making productive use of pupil conceptions in physics education: Developing the concept of force through practical work". Thèse de doctorat, Amsterdam, Université de Vrije.

De Vecchi, G. (2006). Enseigner l'expérimental en classe: Pour une véritable éducation scientifique. Paris: Hachette.

Feltovitch, P. J., Spiro, R. J. et Coulson, R. L. (1993). "Learning, teaching, and testing for complex conceptual understanding". In N. Frederiksen, R.J. Mislevy et I.I. Bejaar (Eds.), Test theory for a new generation of tests, sous la dir. de, p. 181-217. Hillsdale, NJ: Lawrence Erlbaum Associates.

Forbus, K. D. et Gentner, D. (1986). "Learning physical domains: Toward a theoretical framework". In T.2 de R. Michalski, J. G. Carbonell et T. M. Mitchell (Eds.), Machine learning: An artificial intelligence approach (pp. 311-348). Los Altos (Californie): Morgan Kaufman Publishers.

Gaigher, E., Rogan, J. M., et Braun, M. W. (2007). "Exploring the development of conceptual understanding through structured problem-solving physics». International Journal of Science Education, 29(9), 1089-1110.

Gianino, C. (2008). « Microcomputer-based laboratory for Archimedes' principle and density of liquids ». *The Physics Teacher*, 46, 52-54.

Goffard, M. (1992). «Partager le savoir, partager le pouvoir». Science et Vie, no 180 (septembre), p. 84-89.

Greca, I. M., et Moreira, M. A. (2002). "Mental, physical, and mathematical models in the teaching and learning of physics". Science Education, 86(1), 106-121.

Gunstone, R. F., et Mitchell, I. J. (1998). "Metacognition and conceptual change". In J. J. Mintzes, J. H. Wandersee et J. D. Novak (Eds.), Teaching science for understanding: A human constructivist view (pp. 133-163), San Diego, CA: Academic Press.

Halloun, I. (1996). "Schematic modeling for meaningfull learning of physics". Journal of Research in Science Teaching, 33(9), 1019-1041.

Halloun, I. A. (2004). Modeling theory in science education. Boston: Kluwer Academic Publishers.

Hofstein, A., et Lunetta, N. (2004). The laboratory in science education : Foundations for the twenty-first century. Science Education, 88(1), 28-54.

Jonassen, D., Strobel, J., et Gottdenker, J. (2005). Model building for conceptual change. Interactive Learning Environments, 13(1-2), 15-37.

Klir, G. J. (2001). "Conceptual frameworks". Chap. In Facets of systems science (2ème éd., p. 41-69). New York: Kluwer Academic/Plenum Publishers.

Koponen, I. T., et Mäntylä, T. (2006). "Generative role of experiments in physics and in teaching physics: A suggestion for epistemological reconstruction". Science & Education, 15, 31-54.
Legendre, M.-F. (1994). «Problématique de l'apprentissage et de l'enseignement des sciences au secondaire: Un état de la question». Revue des sciences de l'éducation, 20, (4), 657-677.
Legendre, M.-F. (2002). «Le rôle du raisonnement qualitatif dans les processus de changement conceptuel et ses implications pour l'enseignement et la formation des enseignants ». In R. M. J. Toussaint (Éd.), Changement conceptuel et apprentissage des sciences : Recherches et pratiques (pp. 177-201). Outremont, Québec: Les Éditions LOGIQUES.
Llelewyn, D. (2002). Inquiry within : Implementing inquiry-based science standards. Thousands Oaks (Californie): Corwin Press.
Mäntylä, T., et Koponen, I. (2007). "Understanding the role of measurements in creating physical quantities : A case study of learning to quantify temperature in physics teacher education". Science & Education, 16, 91-311.
Marshall, J. A. et Carrejo, D. J. (2008). "Pupils' mathematical modeling of motion". Journal of Research in Science Teaching, 45(2), 153-173.
Méheut, M. et Psillos, D. (2004). "Teaching-learning sequences: Aims and tools for science education research". International Journal of Science Education, 26(5), 515-535.
Mestre, J. P., Dufrene, R. J., Gerace, W. J., et Hardiman, P. T. (1993). "Promoting skilled problem solving behavior among beginning physics pupils". Journal of Research in Science Teaching, 30(3), 303-317.
Métioui, A. et Trudel, L. (2007). Analyse critique des expériences proposées dans les manuels destinés aux jeunes de 8 à 12 ans: Magnétisme, électrostatique et circuits électriques. Cédérom : Critical Analysis of School Science Textbooks, 12 pages, sous la direction de P. Clément, IOSTE International Meeting Tunisia Hammamet, 7 to 10, February, 12 pages.
Mualem, R. et Eylon, B.-S.. (2007). ""Physics with a smile"-Explaining phenomena with a qualitative problem-solving strategy". The Physics Teacher, 45, 158-163.
Nonnon, P., & Métioui, A. (2003). «L'appropriation du processus de vérification expérimentale par des étudiants en formation des maîtres au secondaire : exemple de la diffusion de la chaleur dans un liquide». RES (Revue de l'Enseignement Supérieur), Academica, 21(1), 39-61.
Parsons, Simon. (2001). Qualitative methods for reasoning under uncertainty. Cambridge (Massachusetts): The MIT Press.
Ploetzner, R., et Spada, H. (1998). "Constructing quantitative problem representations on the basis of qualitative reasoning". Interactive Learning Environment, 5, 95-107.
Riopel, M. (2005). Conception et mise à l'essai d'un environnement d'apprentissage intégrant l'expérimentation assistée par ordinateur et la simulation assistée par ordinateur. Thèse de doctorat, Montréal, Université de Montréal.
Safayeni, F., Derbentseva, N., et Canas, A. J. (2005). "A theoretical note on concepts and the need for cyclic concept maps". Journal of Research in Science Teaching, 42(7), 741-766.
Schwarz, C. et White, B. Y. (2005). "Metamodeling knowledge : Developing pupils' understanding of scientific modeling". Cognition and Instruction, 23(2), 165-205.
Siegler, R.S. (2006). "Microgenetic analyses of learning". In W. Damon & R.M. Lerner (Series Eds.), D. Khun et R. S. Siegler (Vol. Eds.), Handbook of child psychology: Volume 2: Cognition, perception, and language (6th ed., pp. 464-510). Hoboken, NJ: Wiley.
Someren, M., et Tabbers, H. (1998). "The role of prior qualitative knowledge in inductive learning". In M. W. Someren, P. Reimann, H. P.A. Boshuizen et T. de Jong (Eds.), Learning with multiple representations (pp. 102-119). New York: Pergamon.
Stavy, R., Tirosh, P. (2000). How pupils (mis-) understand science and mathematics: intuitive rules. New York: Teachers College Press.
Toplis, R. (2007). "Evaluating science investigations at ages 14-16: Dealing with anomalous results". International Journal of Science Education, 29(2), 127-150.
Trempe, P.-L. (1989). «L'enseignement des sciences au quotidien : Six études de cas au primaire et au secondaire (problématique, méthodologie, interprétation, synthèse générale de l'information)». Monographies des sciences de l'éducation, vol. 1, no 1. Trois-Rivières, Université du Québec à Trois-Rivières, 204 p.
Trowbridge, D. E. (1979). "An investigation of understanding of kinematical concepts among introductory physics pupils". Thèse de doctorat, University of Washington.
Trowbridge, D. E., McDermott, L. C. (1980). "Investigation of pupil understanding of the concept of velocity in one dimension". American Journal of Physics, 48(12), 1020-1028.
Trowbridge, D. E., McDermott, L. A. (1981). "Investigation of pupil understanding of the concept of acceleration in one dimension". American Journal of Physics, 49(3), 242-253.
Trudel, L. (2005). Impact d'une méthode de discussion sur la compréhension des concepts de la cinématique chez les élèves de cinquième secondaire. Thèse de doctorat, Montréal, Université du Québec à Montréal.

Trudel, L. et Métioui, A. (2008) . Influence d'une discussion préalable sur la participation des élèves dans un laboratoire de physique du secondaire. Conférence Internationale Éducation, Économie et Société Novotel Paris Tour Eiffel, 17-19 Juillet 2008, CD-ROM, pp. 410-424.
Trudel, L., et Métioui, A. (2010). « Étude exploratoire d'une démarche de formation et de ses effets sur la planification d'une stratégie d'enquête scientifique en physique par de futurs enseignants ». In C. Couture et L. Dionne (Dir.), *La formation et le développement professionnel des enseignants en sciences, technologie et mathématiques* (pp. 151-179). Ottawa : Les Presses de l'Université d'Ottawa.
Trudel, L., Parent, C., & Métioui, A. (2009). Démarche, cheminement et stratégies : une approche en trois phases pour favoriser la compréhension des concepts scientifiques. *Revue des sciences de l'éducation*, 35(3), 149-172.
White, R., et Gunstone, R. (1992). Probing understanding. London : The Falmer Press.

HANDWRITING AND VOICE RECOGNITION APPLICATION FOR STUDENTS WHO NEED SPECIAL EDUCATION

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Abstract: The students who need special education can learn relatively slower than the usual students. To assist and enhance the learning activities for these kinds of students, we have proposed a mobile application in our previous studies. In this study, we have developed two modules that will make it possible to implement all the features of the stepwise learning method. The additional modules are those that can recognize the handwriting of the students and also recognize the voice of the students. In stepwise teaching method, "write" and "say" are fundamental steps. Therefore, with the addition of these modules, the system will be able to recognize the voice and handwriting as well. The main contribution of this study is that the sayings of mentally impaired students are different than the usual students. So, the learning system will include a training system that is dedicated to each student. Furthermore, the handwritings of these students may include many translations and transformations of the images. The learning system will be employed to cover all possible translations and transformations on the images of mentally impaired students. We aim to recognize the voice and handwriting of mentally impaired students with an acceptable rate of accuracy. The system will be tested on real students in the learning process of the digits. This study will be used to enhance the teaching modules for other assistive teaching methods that are currently available.

Keywords: special education, mobile application, stepwise method, rule-based system, voice recognition, handwriting recognition.

Introduction

Because of having portability, Internet, games and social media, mobile devices have become an indispensable part of our lives. For this reason, new applications for mobile devices are being developed every day. Although there are many applications in almost every area, there is not enough study in some areas such as Special Education. Students who need special education may learn slower than other students and consequently may face with learning difficulties. Based on this problem, we proposed an intelligent mobile application that supports the teaching of digits(0-9) in mathematics. This article will explain the two modules of the application: handwriting recognition and voice recognition. Students with mental disabilities may learn slower and need more repetition to reinforce what they have learned. If this kind of applications increases, the students will be able to consolidate what they have learned at school without the limit of time and space alone or under the supervision of teachers. The algorithm of this application designed based on the Stepwise Method; because it is a very effective method to teach mathematics concepts to the students who need special education. In addition, all steps of the Stepwise Method can be applied by using this algorithm.

In the application development process, the handwriting recognition module which will be used in the 'write' step and the voice recognition module which will be used in the 'say' step is not yet completed. The 'do' and 'show' steps are completed. At the same time, the student's responses will be collected in a database and will be designed to provide detailed analysis and reports about the student by using Rule-Based System. Although the language of the application is in Turkish, it can be adapted to other languages in the future. Implementation of all the steps of the Stepwise Method, voice recognition and handwriting recognition modules and the ability to make analyses about the student through the Rule-Based System are the novelties of this study. In application, as in the Stepwise Method, there are four stages to teach a concept; "do, show, say and write". The 16 steps, which are the combination of these, consist of sessions such as do-do, do-show, say-write; where the teacher first teaches the concept and then expects the student to apply it. The part where the teacher explains the concept is adapted with the help of animation and sound in the application. All of the parts that the student "do" and "show" is completed and explained in the previous study.

Methodology

Since this study is about developing a smart application for children in need of special education, the literature review has been done by selecting keywords special education, mobile application, stepwise method, rule-based system, voice recognition, and handwriting recognition. However, since there are not many studies that are similar to the ongoing study and include all keywords, the studies that are included in the literature and partially contain the keywords have been added to the article from the side of our interest. Demands for mobile applications have increased in parallel with the increasing use of smart devices.

Developments Related to Smart and Educational Mobile Applications

The "Intelligent Mobile Learning Interaction System (IMLIS)" provides an environment of mobile learning for people who need special education [8].

"Fingu" is designed for children aged 4 to 8 to develop their arithmetic skills that use a multi-touch feature for iPad devices.

Erkalan, Calp, Şahin, designed an expert system; "Designing and Realizing an Expert System to be Used to Profession Choosing by Utilizing Multiple Intelligences Theory".

Fórtiz, Almendros, and Martínez developed a mobile learning application on IOS devices for students who need special education.

"My Voice" is another application designed for special education. Users can input vocabulary words and the application link these words with pictures.

"A Prototype Mobile Expert System for Nutritional Diagnosis" analyses the eating habits and body characteristics, it makes a proper eating plan for the person.

"A Mobile Application Design for Students Who Need Special Education" aims to teach the students the concepts like short-long, more-less and order the objects.

"Design and Development of a Mobile Learning System For Computer Science Education in Nige¬rian Science Education Context" is a mobile learning system to support teaching and learning of com¬puter science courses.

"1x1 Trainer with Handwriting Recognition" is a mathematical learning application which facilitates the learning and studying of simple multiplications by using handwriting recognition.

"Handwritten Text Recognition: With Deep Learning and Android" offers a new solution to traditional handwriting recognition techniques using concepts of Deep learning and computer vision.

"Mobile Learning Application for Children: Belajar Bersama Dino" proposed the design and development process of Mobile Learning Application which is Belajar Bersama Dino that mainly suitable for children who aged four to six years old including voice recognition capability.

Handwritten Recognition

Handwriting recognition is the recognition of handwritten letters, numbers, and symbols by computer systems. Although this process is quite easy for people, it is a very difficult problem for computers to automatically recognize lines and curves on the ground as letters and numbers, and later on as meaningful words. Today, many documents are still on paper only. It is very important to digitize these documents and transfer the information to the computer. In recent years, great progress has been made in the studies on the recognition of text, so that programs that automatically recognize printed texts on a clean and readable surface have started to enter our lives. On the other hand, the current technology is still limited to handwriting recognition. The difficulty in recognizing handwriting arises from the fact that there are many different types of writing characters and differences from person to person, as well as the letters being interconnected. When handwriting recognition methods become operational, this also saves us from using the keyboard and allows us to type and draw in a much more natural way. Examples of such systems are the electronic agenda (PDA) and other tablet computers.

Methods
Handwriting recognition methods can be divided into two groups: Interactive (online) and non-interactive (offline) methods. Interactive systems are specially designed systems that recognize handwriting at the time of writing. In general, electromagnetic or electrostatic tablets are used. The touches of the pen and the continuity of the movements are considered. Electronic agendas (PDA) is a very common method today. Non-interactive systems are generally the process of trying to recognize the information previously written on paper by digitizing. While interactive systems need to be very fast to keep up with the writing speed, in non-interactive systems, there is no time limitation for the recognition of writing. The advantage of interactive systems is that the shape characteristics of the letters can be observed as well as the movements during writing. Furthermore, one of the greatest benefits of interaction with the user is that errors can be corrected immediately. Non-interactive systems are easier to mislead, as there is no information about the movements during writing, and especially because old documents will not be clean and legible enough.

Non-interactive (Offline) methods
Non-interactive methods are used to recognize the print on paper. First, the document needs to be digitized. Document analysis is the first important step. The document must first be divided into paragraphs and sentences, then into words.

Interactive (Online) methods
Interactive systems are generally systems that automatically detect handwriting or drawings by obtaining coordinates of pen movements by electronic tablets. Although it is faster to use a keyboard to migrate an existing document to a computer, the use of pen and paper is more preferred for creativity and reorganization of documents. Therefore, such systems that interactively recognize handwriting are very important. Two different features are important for correct recognition of letters: static and dynamic properties. Static properties are also used by non-interactive systems, the different sizes of upper and lower case letters, 'g', 'y', 'j' as they lie below the reference line, 'l', 'k', 'b' than other letters long, some letters are dotted. They are important for separating the letters. Dynamic features, which are unique to interactive systems, are similar to where the pen's first touch is when writing a letter, then how the pen follows the movement, and how many times the hand is raised and lowered during a single letter. Interactive systems use both features to recognize handwriting. One of the major advantages of interactive systems is that the user can adapt to the system day by day because it is constant interaction with the user and start writing his writing in a way that it is easier to recognize and also correct errors immediately.

Voice Recognition
Speech recognition is a software or hardware that the ability to translate the human voice to a form that computer can understand. This kind of recognition is frequently used to control a device, do tasks, or write without using a keyboard, mouse, or press any buttons. Nowadays, it is accomplished on a computer by using Automatic Speech Recognition(ASR) software programs. A lot of programs that have ASR capability need the user to "train" the ASR program to recognize their voice. By doing that, it can more accurately transform the speech to text. There are two types of speech recognition. One is called speaker-dependent and the other is speaker-independent.

Speaker Dependent Voice Recognition System
Speaker–dependent software is commonly used for dictation software, while speaker–independent software is more commonly found in telephone applications. Speaker–dependent software works by learning the unique characteristics of a single person's voice, in a way similar to voice recognition. New users must first "train" the software by speaking to it, so the computer can analyze how the person talks. This often means users have to read a few pages of text to the computer before they can use the speech recognition software.

Speaker Independent Voice Recognition System
Speaker–independent software is designed to recognize anyone's voice, so no training is involved. This means it is the only real option for applications such as interactive voice response systems. The downside is that speaker–independent software is generally less accurate than the speaker–dependent software.

Stepwise Method
The Stepwise Method, is developed by Cawley, which is a teaching method for learning mathematical concepts that are mostly applied to the students who have special education needs. There are 16 steps in this teaching method, which is the dual combination of the steps of “do, say, show and write”. During the implementation of the method, the teacher first explains a concept and then asks the student that concept. For example, in step do-do, the teacher does and asks the student to do it; or the teacher says and then asks the student to write (say-write). There are 4 sets of tools in each step and these sets are implemented one after the other. If the student responds correctly to the three of the 4 sets of sessions, the criteria are met and proceeds to the next step. To be able to apply

this method, students should have some abilities: touch, rhythmic counting, readiness to distinguish between concepts less; also should understand and apply such instructions like saying, receiving, giving, showing, etc. However, the names of symbols in the toolsets to be used to teach the numbers must also be well known by the student.

All steps of the Stepwise Method are shown in Table 1.

Table 1: Teacher / Student interaction in Stepwise Method.

Teacher/Student	DO	SHOW	SAY	WRITE
DO	*DO-DO*	*DO-SHOW*	*DO-SAY*	*DO-WRITE*
SHOW	*SHOW-DO*	*SHOW-SHOW*	*SHOW-SAY*	*SHOW-WRITE*
SAY	*SAY-DO*	*SAY-SHOW*	*SAY-SAY*	*SAY-WRITE*
WRITE	*WRITE-DO*	*WRITE-SHOW*	*WRITE-SAY*	*WRITE-WRITE*

Methodology

Our motivation is to develop an application to teach numbers to the students with mild mental retardation who have only a few studies in the literature. In this context, we deemed it appropriate to adopt the Stepwise Method, which is a very successful and frequently used method to teach mathematical concepts to the children who need special education. The "write" session in which the student will respond by writing, will be performed by using handwriting recognition and the "voice" session which the student will respond by talking, will perform by using voice recognition. Using this application with mobile devices allows the student to repeat a concept as many times as he/she needs anywhere. This will speed up learning.

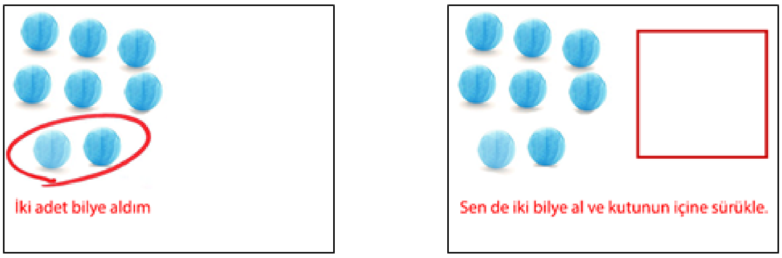
Adaptation of Stepwise Method to the Mobile Application

In the mobile application, this method will be applied as follows: First of all, while setting research subjects, students will be selected to have a well understanding of less-than-concept and to be able to demonstrate prerequisite behaviour of rhythmic counting from 1 to 10. It is also expected that subjects will have basic self-care skills (toilet, eating, and dressing), matching skills in terms of concepts and recipient language skills. The two-word directions should be understood and their fulfillment is important in terms of using this practice.

Before the training, the student is asked whether knows the material to be used in this session (eg. do-do steps/marbles). If the student answers correctly, the training begins. Otherwise, the program quits to the main menu. This question is repeated if the student does not respond to a question asked(10s), or if the question is answered incorrectly. If the student does not answer the question or gives wrong answers three times, the program gives a clue to the student. The same question is asked again after the clue is given. If the student remains unresponsive or gives a wrong answer 3 times, the application will move to the next step and the student will be considered unsuccessful in this session. At the end of a step, if the student knows at least 3 out of 4 (75%) of the questions asked in 4 sets, the criterion is deemed valid and the next step is taken. There are 16 steps in the teaching of each concept. They are applied by the teacher-student interaction, therefore, an iterative algorithm will be applied by changing the steps.

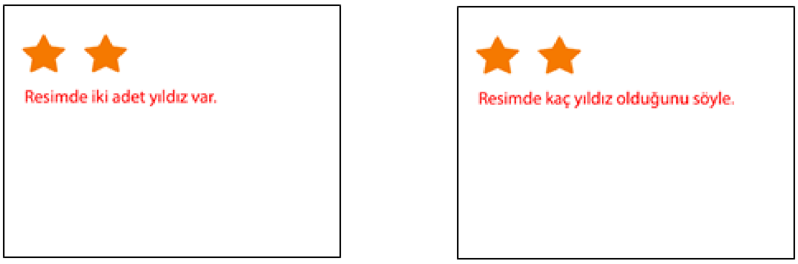
Teaching the Concept of Numbers

Figures 2 through 5, the sample animations are shown. On the left, the animations are shown instead of the teacher in real life. The Figures on the right are the realization of what the students do in real life by saying, touching, dragging or writing in the program.



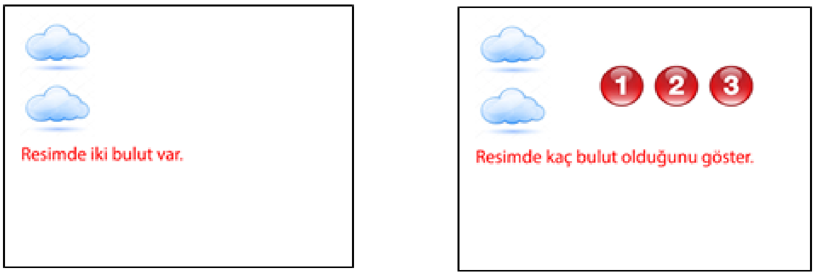
(a) (b)

Figure 2. *Do-Do (Yap-Yap in Turkish) Step: (a) the application shows how to take two marbles. (b) The student is asked to drag two marbles into the box.*



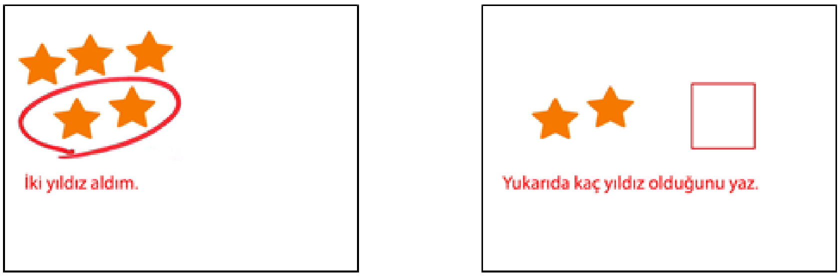
(a) (b)

Figure 3. *Show - Say(Göster - Söyle in Turkish)*: Step *(a) the application shows two stars. (b) the student is asked to say the number of stars.*



(a) (b)

Figure 4. *Show – Show (Göster-Göster in Turkish) Step: (a) the application shows two clouds. (b) the student is asked to show the number of clouds.*



(a) (b)

Figure 5. *Do - Write (Yap - Yaz in Turkish) Step:(a) the application shows two stars. (b) the student is asked to write the number of stars.*

As already stated, the instructions and tips given by the teacher are provided as animations in the application. When the student's response is expected, various tools will be used to respond to by doing, showing, saying and writing according to the application stage. In the do step, the drag and drop feature will be used to drag the desired amount of the items to the desired area. In the show phase, the touch feature will be used, so that the student can show the item at the desired amount. In the say phase, when the student says the number of items, voice recognition will be used so that the application can identify this voice. In the write phase, handwriting recognition will be used, so that the application can verify whether the written digit to the desired region is correct or not.

The Interface

The application “Rakamları Öğreniyorum” – ‘I am Learning Digits’ aims to teach digits(0-9) with mild mental disabilities. The application is being developed by using the Java Programming Language on the Android Studio platform.

The Figure 6 shows the authentication screen of the program. If user has already registered, he/she can login by pressing the orange button(GİRİŞ) otherwise, user has to press the pink button(KAYIT OL) to go to the register screen(Figure 7). When user login successfully, opening screen appears as shown in Figure 8.

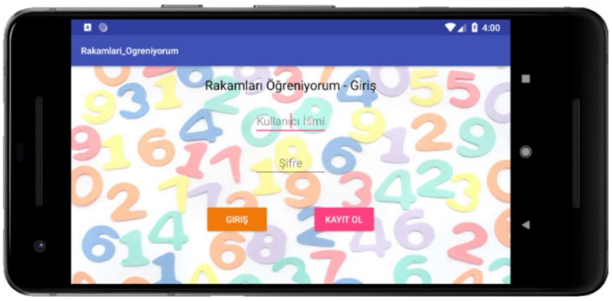


Figure 6. *Login screen.*

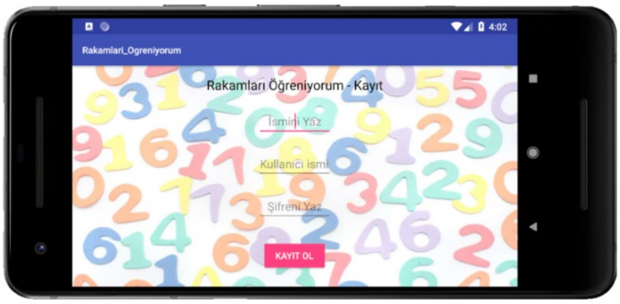


Figure 7. *Register screen..*

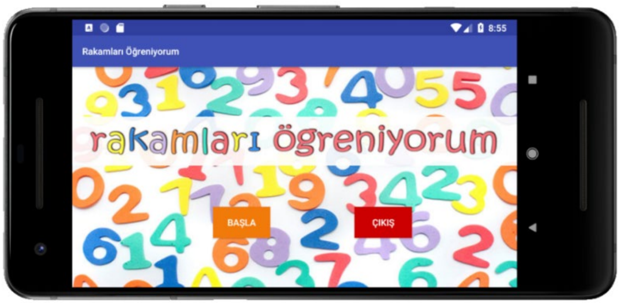


Figure 8. *Opening screen of the program(After successful login).*

In real life Stepwise Method is accomplished with the teacher. The owl was used as a tutor because it represented wisdom here, shown in Figure 9.

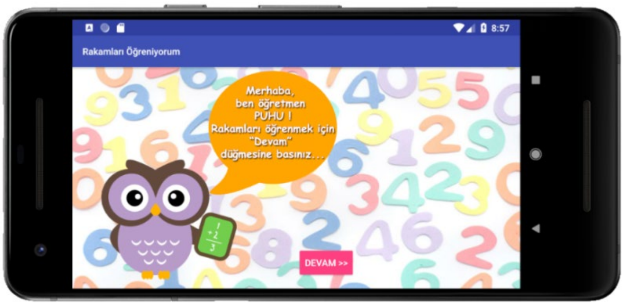


Figure 9. *Teacher Puhu.*

The application starts with do-do step and applies all steps in sequence. However, before the training, it is checked whether the materials to be used in that step are known to the student. An example is provided in Figure 10.

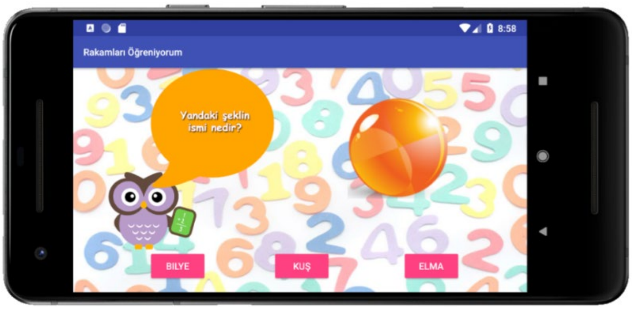


Figure 10. *The block diagram of the application (numbers in the diagram indicates the order of processing).*

In the first structure of the do-do step, the student is given information about the concept with the help of an animation; In the second build step, the student is expected to perform the required application by giving a directive, as shown in Figure 11.

Figure 11. *Student is informing about the concept.*

For example, when applying the do-do step of concept 2, the student is expected to use the drag-and-drop feature to move the ball from left to right as desired. If the student does it correctly, the application moves to the next stage. If the student does wrong, the application asks the same question again. It gives a hint when it doesn't know 3 times. If it does not know 6 times in total, the program moves to the next stage. Figures 12 and 13 show related screen shots.

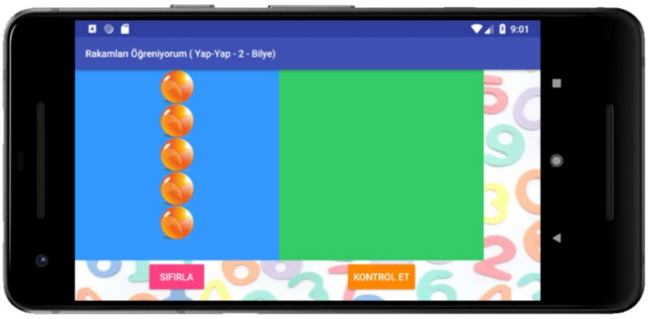


Figure 12. *Student is expected to drag and drop 2 marbles.*

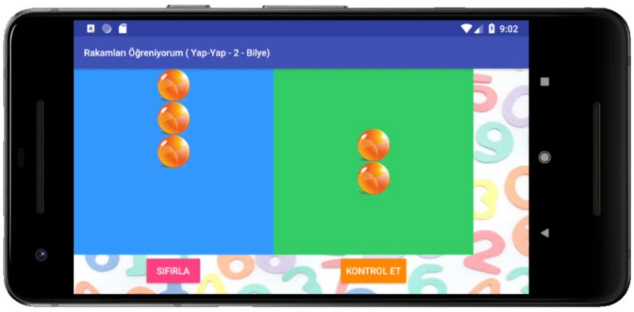


Figure 13. *Two marbles are dragged. Program will pass to next stage if student presses "kontrol et(check)" button.*

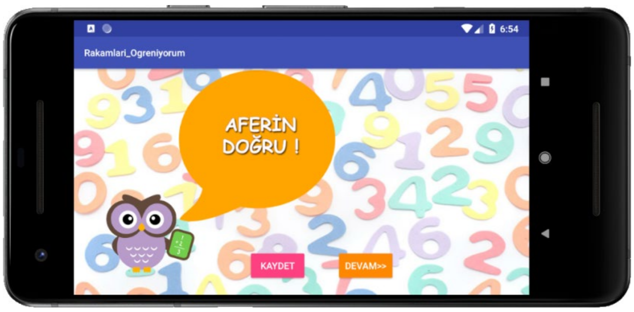


Figure 14. *If the student answers correctly, this screen appears.*

Implementation of Handwritten Recognition System to the Mobile Application

Handwritten Recognition is a method used to read a handwriting, recognize and transfer it to computer as optical characters. By adapting the handwriting recognition method to the application, the "write" session will be held by the student using the Stepwise Method. Studies related to this module are in progress. Mentally disabled individuals may experience difficulties while writing; for example, writing slower than normal peers, the letter or number is skewed, unable to write without raising his hand. For this reason, these are taken into account when developing the handwriting diagnostic system.

In the handwriting recognition module, the student is expected to write down the result in the blank box next to the symbols shown in the Figure 15.

Figure 15.*Student has to draw a number into the grid.*

The module is developing using TensorFlow software in Android Studio. Tensor flow is an open source deep learning library. Convolutional Neural Network will be used as Handwriting Recognition Algorithm. CNN have been widely employed for image recognition applications because of their high accuracy, which they achieve by emulating how our own brain recognizes objects.

Machine learning only works more accurately with a lot of data. So it is needed handwritten number samples to get started. MNIST data set of handwritten numbers will be used as samples.

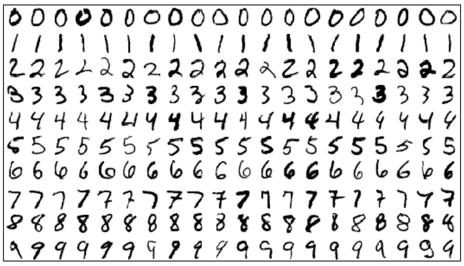


Figure 16. *Some numbers from the MINST data set.*

The next step is to use a neural network to take numbers as input. Neural networks are a set of algorithms, modeled loosely after the human brain, that are designed to recognize patterns According to a computer, an image is really just a grid of numbers that represent how dark each pixel is:

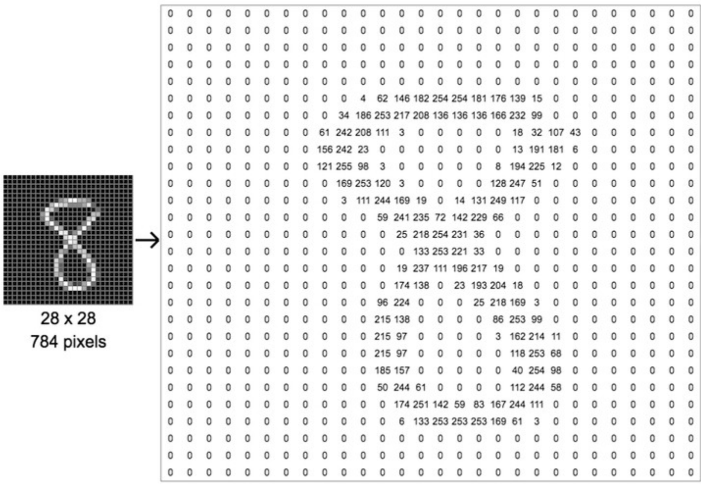


Figure 17. *To a computer, an image is really just a grid of numbers that represent how dark each pixel is.*

In this process, it will not be difficult to define a number that is properly written to the centre. The main problem is the numbers written on the edges that are not in the centre. These will not give proper results in a poorly designed handwriting identification system and will result in low accuracy of the system. There are several ways to solve this problem: One of them to use the Brute Force Algorithm to scan a grid frame by frame, the other one is using Brute Force Algorithm to store an image file in the system for every possible position. But, the most effective method is to use Convolutional Neural Networks. The idea is to divide the image to several pieces by sliding window search and save each result as a seperate image tiles. The next thing is to fed a single image into a neural network to see if it was an "8". The same implementation will be done for each individual image tile by keeping the same neural network weights in the same original image.

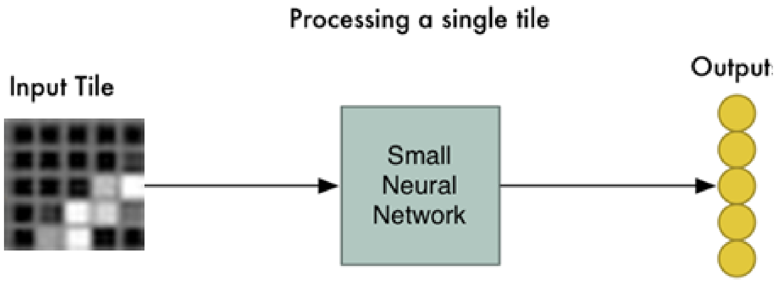


Figure 18.*Feed each image tile into a small neural network.*

Then the results from each processed tile will be saved into a new array. The next step is to make downsampling because the array is still big.

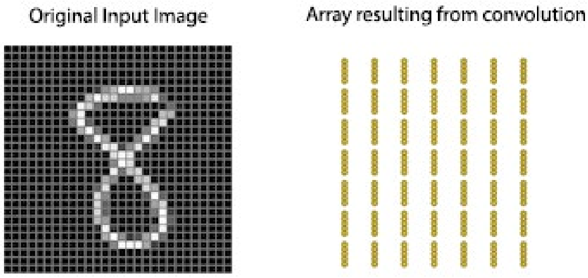


Figure 19. *To reduce the size of the array, we downsample it using an algorithm called max pooling.*

To reduce the size of the array, max pooling algorithm will be used. The algorithm checks each 2x2 square of the array and keep the biggest number. Eventually, the image is down to a small array. It is more suitable to use that array as inputs of another neural network.

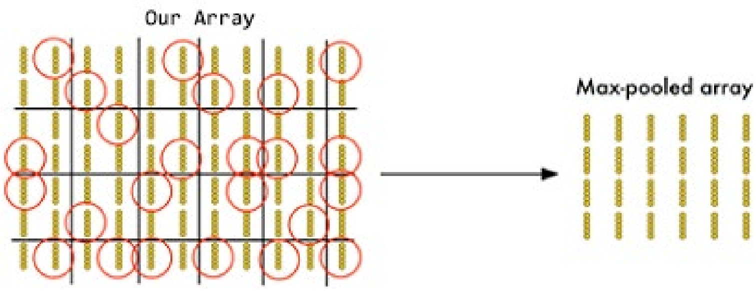


Figure 20. *Algorithm checks each 2x2 square of the array and takes the biggest number.*

This final neural network will decide if the image is or isn't a match. To differentiate it from the convolution step, it is called as "fully connected" network which it is shown in Figure 21.

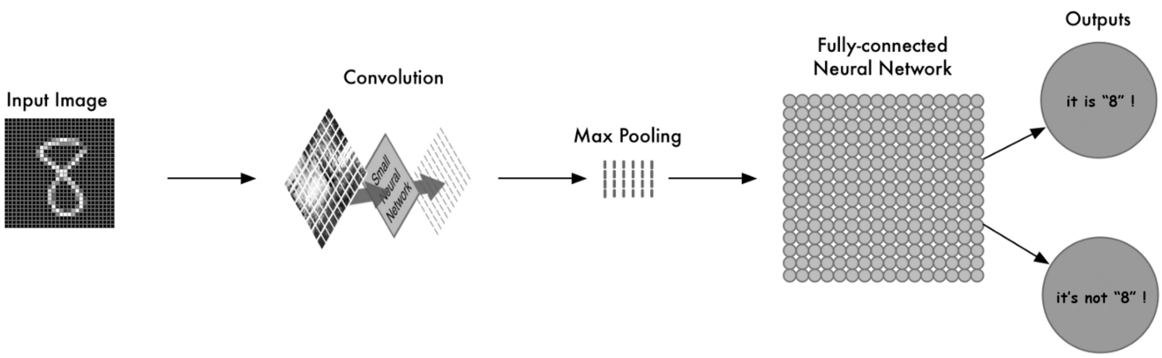


Figure 21. *Fully connected network.*

The use of convolutional neural networks is a conventional method. The main challenge is that the students who need special education, have very different and unique style of writing. Instead of the conventional training phase including training set images, we are planning to propose a subject based training algorithm. Where, each student's writing style will be trained as a seperate classifier.

Implementation of Speech-to-Text Recognition System to the Mobile Application

In the speech-to-text recognition module, the student is expected to say the result by pressing the microphone. Speech-to-text recognition is a tool that has the ability to process the human voice and decode it as text. By adapting the speech-to-text recognition method to the application, the student's "say" session of The Stepwise Method will be held.

Figure 22. *Student has to talk by pressing the microphone button.*

For children with special educational needs, acquisition of the mother tongue is one of the areas that may be problematic. Children affected by various degrees of mental disabilities may experience problems in both receptive and expressive language development (slower speaking, stuttering, swallowing some words). Therefore, taking speech samples of normal individuals and trying to understand what a mentally disabled child is saying during the voice recognition process may result in low accuracy. For this reason, the voice samples of each student will be taken before they come to the saying part of the program. The program will do this itself during the flow process of the program. To overcome this challenge, a subject-based training algorithm will be developed to achieve accurate speech recognition.

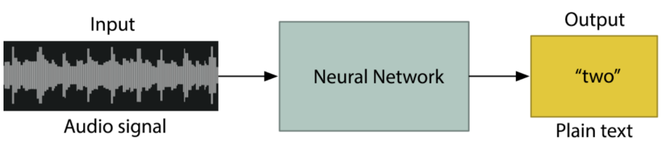


Figure 23. *Neural machine translation*

In the implementation, each student's voice will be trained to the system with the help of the teacher using the program. After the student's voice has been trained, the given answer will be recorded as a one-dimensional sound wave. After acquiring the audio input, it will be fed into a deep neural network. The input to the neural network will be sufficient audio chunks. For each little audio slice, it will try to figure out the letter that corresponds to the sound currently being spoken.

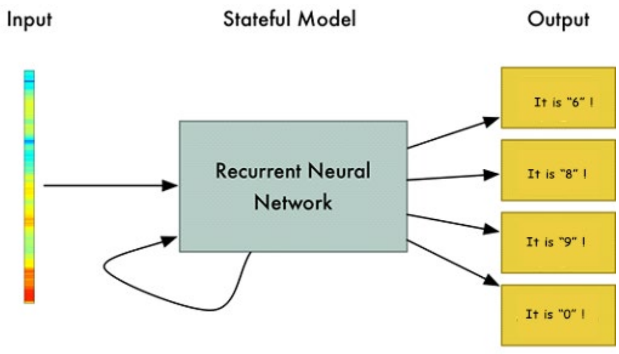


Figure 24. *The model's current state influences the next calculation.*

Recurrent neural network will be used for estimations because it is a neural network that has a memory to influence the future predictions. By having that memory of previous predictions helps the neural network make more accurate predictions going forward.

Block Diagram of The Application

The overall process consists of three main blocks shown in Figure 12. Each block contains teacher guidance. In the beginning of the presentation, application checks whether the student knows the object of the educational set to be used. If the answer is true, education begins, otherwise application returns to main menu. Student will count as successful, if the student answered correctly among 3 of the 4 material sets presentations.

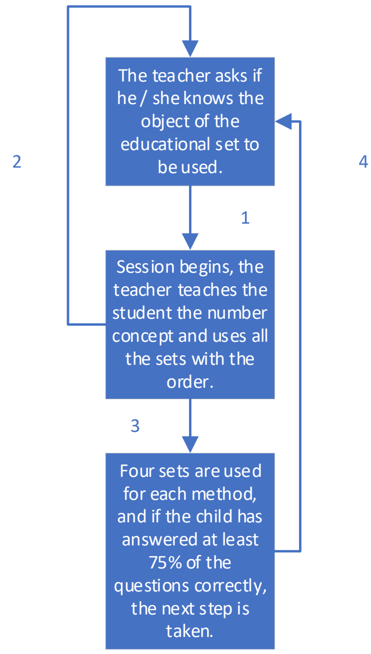


Figure 25. The block diagram of the application
(numbers in the diagram indicates the order of processing).

The Flowchart of the Overall Process

This flowchart given in Figure 13 shows the teaching process of the digit 2. The same algorithm will be applied to all numbers. In the flowchart; item_set[ ] is an array for item set pictures to demonstrate the teaching part and set_no is the index of item sets. Pictures will be taken from image database. The objects of item sets are shown below:

item_set[0]=beads
item_set[1]=buttons
item_set[2]=erasers
item_set[3]=lids

There will be 16 steps in this algorithm and in each step, the four item set will be shown to the student in an orderly manner. During the teaching process, if necessary, a hint picture will be shown to the student.

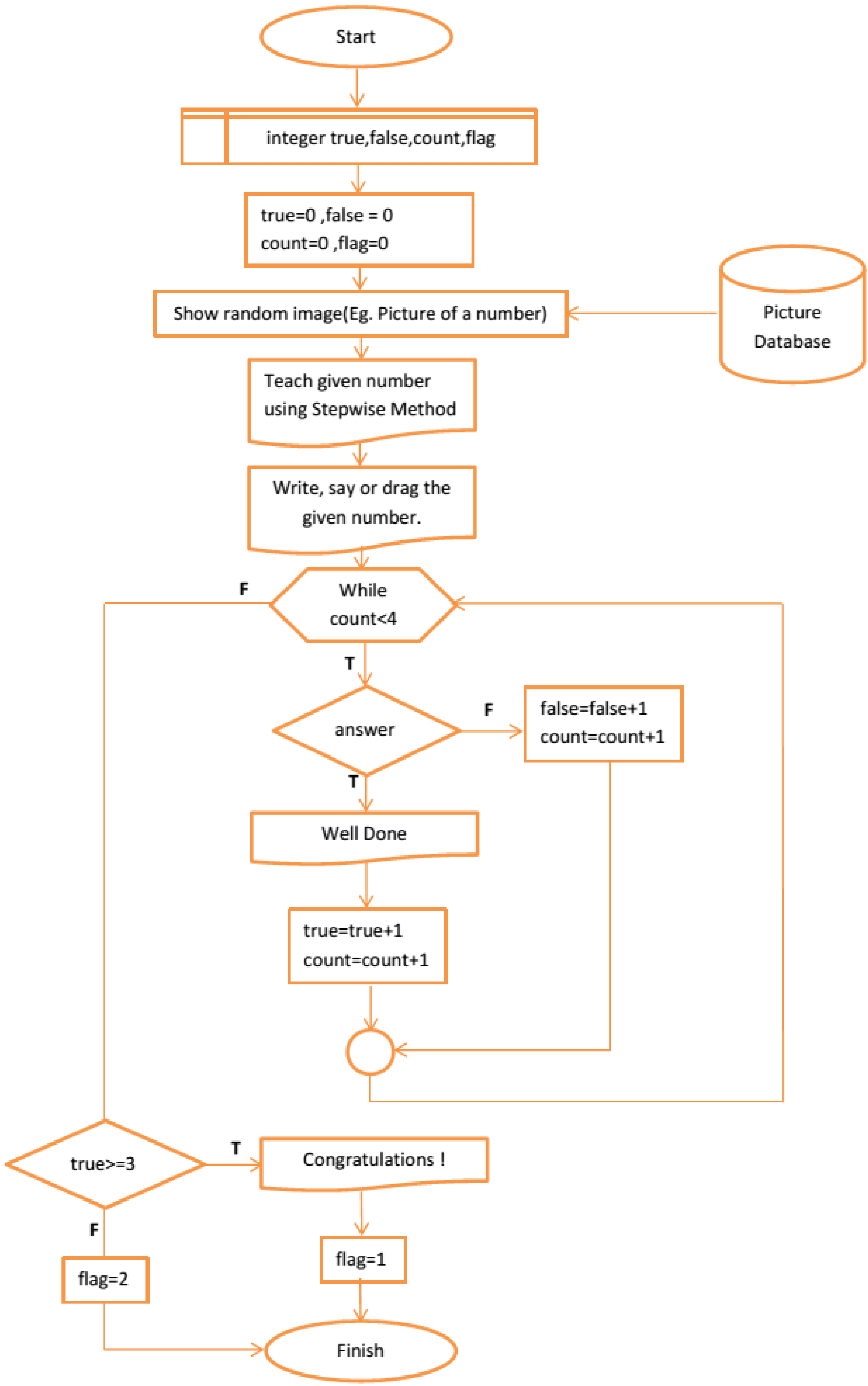


Figure 26. The generic flowchart of the teaching module.

Application Platform

The application is developed in Android Studio platform, based on Java Programming Language. In order for users to be able to run this application, the operating system installed on their smart phones or tablets must be at least Android 4.0 (Ice Cream Sandwich).

Android Studio has been chosen as a program development environment; because, Android-powered devices are much more common than the others, currently in the marketplace. According to the Netmarketshare.com, year 2018 market share of operating systems for mobile devices are: IOS (29.29%), Android Studio (68.93%) and other (1.65%). Also, Android-powered devices are cheaper and more accessible than other competitors [14].

Conclusion

This article contains information about two modules of an application written to assist teaching numbers to children who need special educational. The application aims to use the Stepwise Method, which is a very effective method used to teach mathematics to children in need of special education, in all aspects. The proposed application is aimed to assist the teacher during education. In brief, this system consists of several sessions where the teacher first informs the child about the desired concept and then expects the child to respond to the same concept. The sessions are a total of 16 and can be exemplified by the combination of do, say, show, and write. For example, the do-show step consists of sessions that the teacher does through the training and asks the student to show. I bought two marbles from the stack, and you show me which card have two marbles. The teacher side in the application is designed with animation. In the sections that the student will apply, the stages of make and show were explained in the previous article. What is described here is how to integrate the write and say steps into the application. At the write level, the student is expected to write the answer to the question asked where the application applies handwriting recognition methodology. In the say step, the student is expected to answer the question by speaking. Then the application applies enhanced speech recognition methodology. Both modules will be designed using Deep Learning. The novelty in this part is that the neural networks will employ subject based training phase. The unique feature of this work is that the system is designed to implement all the steps of the Stepwise Method.

References

Zeki, U. & Karanfiller, T & Yurtkan, K. (2019). An Intelligent Mobile Application Design Based On Stepwise Method Supporting Special Education. *International Symposium on Engineering, Artificial Intelligence & Applications.*

Zeki, U. & Karanfiller, T & Yurtkan, K. (2018). An Extended Mobile Application Design For Special Education To Teach Numbers. *International Conference On Perspectives In Future Education*.

Karanfiller, T., Göksu, H., & Yurtkan, K. (2017). A Mobile Application Design for Students Who Need Special *Education. Education & Science/Egitim ve Bilim, 42(192).*

Cawley, J. F., & Vitello, S. J. (1972). Model for arithmetical programing for handicapped children. *Exceptional Children*, *39*(2), 101-110.

Balçık, B. (2015). Zihinsel yetersizliği bulunan öğrencilere etkileşim ünitesi yöntemiyle toplama becerisinin öğretimi. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi*.

Oyelere, S. S., Suhonen, J., Wajiga, G. M., & Sutinen, E. (2018). Design, development, and evaluation of a mobile learning application for computing education. *Education and Information Technologies*, *23*(1), 467-495.

FernáNdez-LóPez, Á., RodríGuez-FóRtiz, M. J., RodríGuez-Almendros, M. L., & MartíNez-Segura, M. J. (2013). Mobile learning technology based on iOS devices to support students with special education needs. *Computers & Education*, *61*, 77-90.

Barendregt, W., Lindström, B., Rietz-Leppänen, E., Holgersson, I., & Ottosson, T. (2012, June). Development and evaluation of Fingu: A mathematics iPad game using multi-touch interaction. In *Proceedings of the 11th international conference on interaction design and children* (pp. 204-207). ACM.

Zare, S. Intelligent Mobile Learning Interaction System (IMLIS). *A Personalized Learning System for People with mental Disabilities Department of Mathematics and Informatics, University of Bremen*.

Campigotto, R., Mcewen, R., & Epp, C. D. (2013). Especially social: Exploring the use of an iOS application in special needs classrooms. *Computers & Education*, *60*(1), 74-86.

Netmarketshare (2019), Available: http://www.netmarketshare.com.

Rabko, M., & Ebner, M. (2018). 1x1 Trainer with Handwriting Recognition. *International Journal of Interactive Mobile Technologies (iJIM), 12(2), 69-79.*

Yahaya, N. S., & Salam, S. N. A. (2014). Mobile Learning Application for Children: Belajar Bersama Dino. *Procedia-Social and Behavioral Sciences*, *155*, 398-404.

IN SILICO ANALYSIS FOR CHARACTERIZING THE STRUCTURE AND BINDING PROPERTIES OF ALA-HIS-LYS (AHK) TRIPEPTIDE

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Abstract: AHK (Alanine-Histidine-Lysine) tripeptide, known as an antioxidant because of its amino acid properties, has been clinically developed for the treatment of hair loss and skin rash. The copper complex of this tripeptide (AHK-Cu) is an analog with a stronger effect than the Gly-His-Lys (GHK-Cu) tripeptide which is used for hair growth. The effects of AHK-Cu on human hair growth were evaluated by *in vitro* studies (Pyo, 2007) and the results showed that AHK-Cu promotes the growth of human hair follicles. In addition, Vitamin C conjugated AHK has been developed to increase collagen synthesis and promote human dermal fibroblast growth. These results provided important data for the development of peptide-based bone regenerative agents for the treatment of bone-related disorders (Jung, 2018).

The aim of this study is to determine the most stable geometric structure of AHK tripeptide by using theoretical methods with different approaches to determine the binding properties with proteins that can act in the body.

Firstly, the most stable molecular structure of tripeptide was determined with the help of quantum mechanical method, which included electronic interactions in the calculation. Then, the most efficient structure of the tripeptide in the water medium such as the human body was determined using Molecular Dynamic (MD) analysis. In addition; the binding properties of title tripeptide was investigated by molecular docking technique. The discovery and improvement of the structure and activity of cosmetic peptide is an active field of study, particularly in biochemistry and pharmacology.

Keywords: AHK, L-Alanine-L-Histidine-L-Lysine, tripeptide-copper complex, DFT, MD, Molecular Docking

Introduction

Drugs are a very important factor that affect human life and health. Unfortunately, the discovery of molecules result in safe and effective drugs involves a process that has high cost, production, development and testing stages; they must go through certain stages as a result of the experiments performed in the laboratory, and then include clinical research. Designing and developing the most effective drug in a short time and with lower costs attracts the attention of many scientists working in different fields. In the process of designing the most effective drug, *in silico* methods are preferred because it minimizes time and cost. The appropriate drug structures obtained in accordance with the calculations made with *in silico* methods also allow more rational drug designs by reducing the processes of organic synthesis with high budget. The aim of molecular modeling methods that define molecular systems at the atomistic level is to show how atoms and molecules can interact with a three-dimensional image and simulation, and to determine the structure of these interaction mechanisms. These models can also be used to interpret existing observations or to predict new chemical behaviors. In the drug design process, in silico methods have become a valuable and necessary tool for the modeling of molecular structures that have been nominated for drugs, for increasing the effectiveness of drugs, and for the design of new drug molecules with unknown molecular structure. With these methods, it is possible to examine the relationship between chemical structure and function from small systems to large biologic molecules and material groups. The contribution of modern computer-aided drug design to the discovery of drugs is an indisputable fact and is understood to have been used by large pharmaceutical companies in many commercially available drugs. Modern computer-aided drug design has contributed to the discovery and development of many medicines such as Captopril, Dorzolamide, Saquinavir, Zanamivir, Oseltamivir, Aliskiren, Boceprevir, Nolatrexed, Rupintrivir, and NVP-AUY922.

AHK (Alanine-Histidine-Lysine) tripeptide which shows antioxidant effect because of its amino acid properties, has been clinically developed for the treatment of hair loss and skin rash (Rushton, 2002 and Shimura, 2017). It is claimed that copper peptides can increase hair follicle size and create a healthier environment for the growth of scalp hairs. AHK copper complex (AHK-Cu) is an analog of Gly-His-Lys copper complex (GHK-Cu), which has antioxidant and anti-inflammatory effects, is recommended for wound healing, enhancing the effect of immune cells, stimulating collagen synthesis, skin fibroblasts and the growth of blood vessels. The effects of AHK-Cu on human hair growth were evaluated many *in-vitro* and *ex-vivo* studies (Pyo, 2007) and it also promotes the growth of human hair follicles (Patt, 2009). It provides an increase dermal cell multiplication and viability to help to production of collagen (Patt, 2010). It has also stronger effect than GHK-Cu for hair growth. Vitamin C conjugated AHK has been developed to increase collagen synthesis and promote human dermal fibroblast growth. These results provided important data for the development of peptide-based bone regenerative agents and for the treatment of bone-related disorders (Jung, 2018). The aim of this study is to determine the most stable molecular structure of AHK tripeptide, which is a very effective field of cosmetic use, and to identify the binding mechanisms by proteins with which it acts.

Materials and Methods

Molecular Dynamic Method

Molecular Dynamic Simulation was performed using the GROMACS software (version 5.1.2) (Van Der Spoel, 2005) to determine the conformational change in the water medium on the optimized geometry, calculated at DFT/B3LYP level of theory with the 6-311++ G (d,p) basis set, of the AHK in the vacuum medium obtained by the Gaussian 09 software program (Frisch, 2009). Initially, the GROMOS96 54a7 force field (van Gunsteren, 1996) was chosen where the topology file would be created to perform molecular dynamic simulation. AHK tripeptide was placed at the center, a distance of 1.0 nm between the outside of the molecule and the edge of the solvent box, and simulated with water medium. The cubic box was filled with 978 moles of SPC (simple point charge) water (Smith, 1993) mediums and two Na+ and three Cl- ions were added in the cubic box to neutralize the system. The steepest descent method was chosen for the energy minimization at 200 ps for water medium. To equilibrate the temperature and pressure of the systems, NVT (50 ps) and NPT (500 ps) ensembles were carried out for 310 K temperature using a V-rescale thermostat (Bussi, 2007) and 1 bar pressure using the isotropic Parrinello-Rahman barostat (Parrinello, 1981). To obtain the trajectory files during 5 ns for analysis the systems behaviors', Molecular dynamics (MD) simulations were performed by applying periodic boundary conditions in all three directions. Leap-frog algorithm was used in equation of motion was united in order to generate time-dependent trajectories. All bond lengths were constrained with the LINCS (linear constraint solver) algorithm (Hess, 1997). The Particle Mesh Ewald (PME) method (Darden, 1993) was used to calculate the long-range electrostatic interaction with a grid width of 0.16 nm and a fourth order cubic interpolation. Verlet cut-off scheme (Verlet, 1967) was used with a 0.8 nm cut-off radius for identified the cut-off distances, the van der Waals and the short-range electrostatic interactions. The atom coordinates, velocities and energies were saved every step and obtained the trajectory files. The resulting of trajectory files were viewed and analyzed with the VMD software (Humphrey, 1996).

Molecular Docking Method and ADME Analysis

The molecular structure of the AHK tripeptide, which was subjected to molecular dynamics simulation in the water medium for 5 ns at GROMACS program introduced to Schrödinger Maestro program for use as a ligand in the calculation of docking. Schrödinger Lig Prep module was used to prepare ligand to docking analysis. AHK was prepared for docking calculations using the OPLS3 force field (Harder, 2015). A maximum of 24 stereoisomers were produced for the ligand after the ionization states at pH 7.0 ± 2.0 were selected. The tripeptide-copper complex, defined as a growth factor, stimulates the proliferation of dermal fibroblasts and increases vascular endothelial growth factor production, while at the same time decreasing the secretion of transformed growth factor-beta1 by dermal fibroblasts. For this reason, Vascular endothelial growth factor receptor 2 (pdb code: 3VO3) (Miyamoto, 2013) was prefered as a receptor and was prepared with Protein preparation wizard tool (Sastry, 2013) in Schrödinger software. The docking analysis of AHK tripeptide onto a vascular endothelial growth factor receptor-2 was performed. The receptor was obtained from the PDB database but due to the lack of residues in the protein structure, the crystal structure was obtained using the SWISS-MODEL server (Bienert, 2016). All waters, metals and ions except protein were deleted from the data file. The polar hydrogens were added to the heavy atoms in the protein. The bond orders were assigned, charges were defined at pH 7.0 and the selected receptor was optimized using PROPKA (Søndergaard, 2011). The heavy atoms in the receptor were converged by preferring 0.3A˚ RMSD and the OPLS3 force field. After the grid was generated using glide grid generation tool, drug candidate molecule was docked to the receptors using Glide SP (standard precision) module of the Maestro version 11.4 (Friesner, 2006; Friesner, 2004; Halgren,2004). Determination of the pharmacokinetic properties of drug candidate molecules is very important for the design and synthesis of drugs with better bioavailability. The drug candidate compounds which easily absorbed orally, easily transported to the target region (skin, stomach, blood brain barrier) in the body and easily removed from the body are determined by ADME profiles which are required by the FDA in the drug approval process (Ntie-Kang,2013). The Qik-Prop module was used to determine the ADME profile of the AHK tripeptide.

Results and Discussion

Molecular Dynamics Results

Molecular Dynamic Simulation was performed using the GROMACS software (version 5.1.2) to determine the conformational change in the water medium on the optimized geometry, calculated at DFT/B3LYP level of theory with the 6-311++ G (d,p) basis set, of the AHK in the vacuum medium obtained by the Gaussian 09 software program. The AHK tripeptide was trapped in 978 moles of water molecule and two Na+ and three Cl- ions were added to ensure system neutralization in **Fig.1**. For the energy minimization, the steepest descent method was chosen at 200 ps for water medium in **Fig. 2.** Using the NVT (50 ps) and NPT (500 ps) assemblies, the temperature and pressure of the system were brought to 310 K and 1 bar, respectively, and a 5 ns Molecular dynamic (MD) simulation was performed, thereby examining the conformational change of the peptide in a similar environment to the human body. During the simulation, the RMSD value of AHK tripeptide in water medium was found to be in the range of 0.02 - 0.1 nm in **Fig. 3.** A rmsd of about 0.2 nm or less indicates that the peptide is in its original crystal form. The Rg change graph was also plotted for 5 ns. According to this graph, the constant Rg value to a relatively constant mean tells us that the peptide has stable structure in the water medium in **Fig.4.**

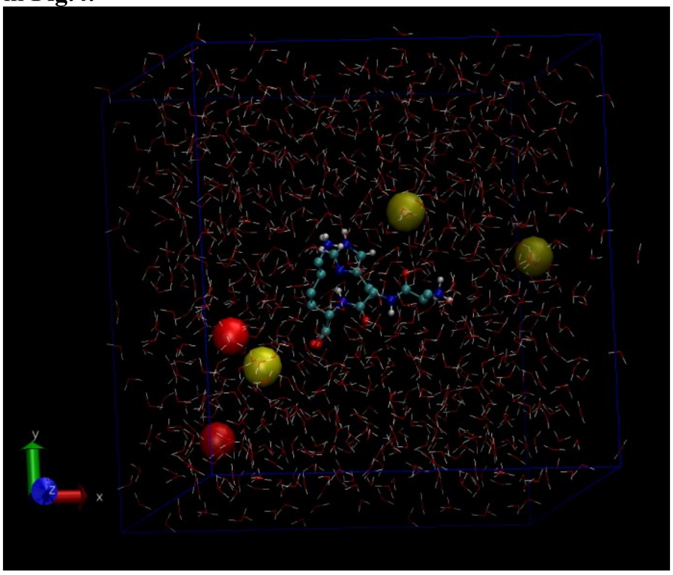

Figure 1: AHK tripeptide in a cubic box solvated with 978 SPC water molecules with two Na^{+} and three Cl^{-} ions.

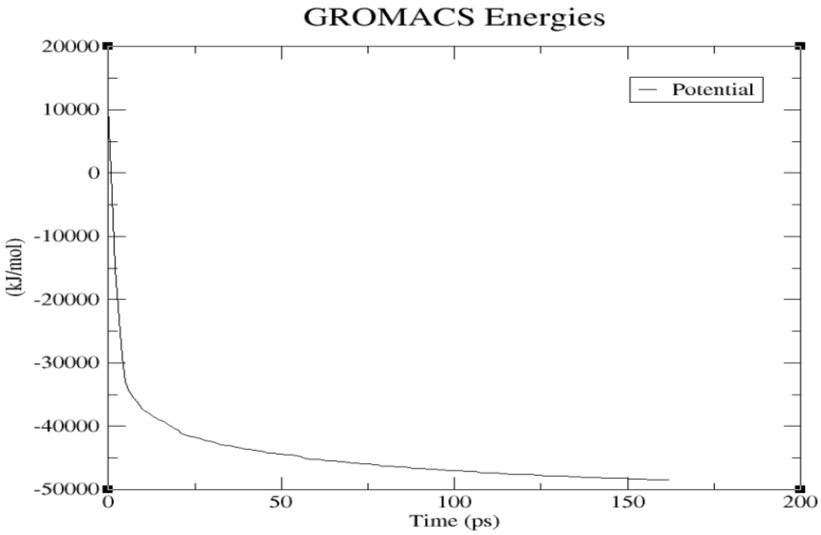

Figure 2: The potential energy minimization of the system using the Steepest Descent algorithm for water medium system of AHK tripeptide.

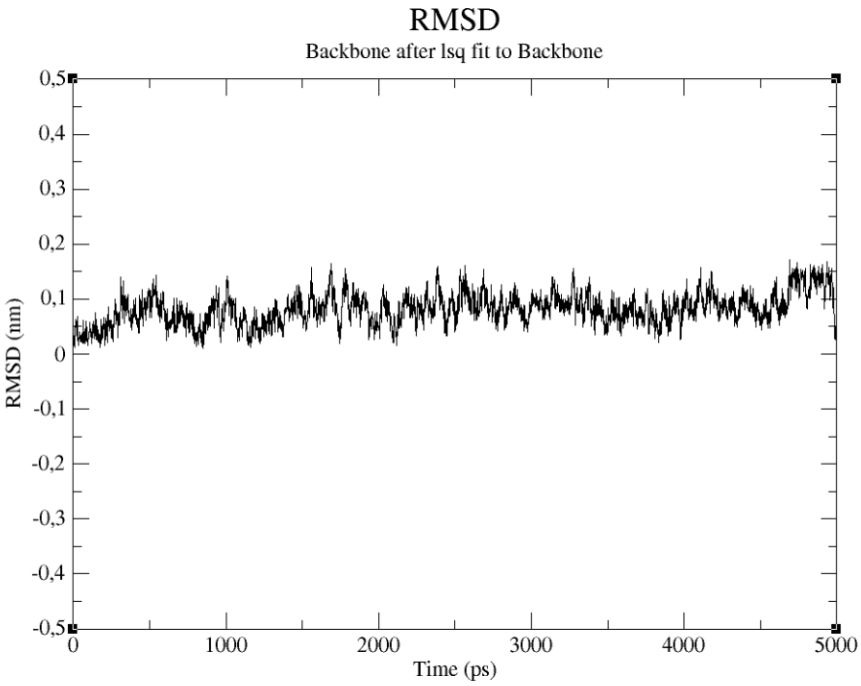

Figure 3: The RMSD values of the water medium system of AHK tripeptide.

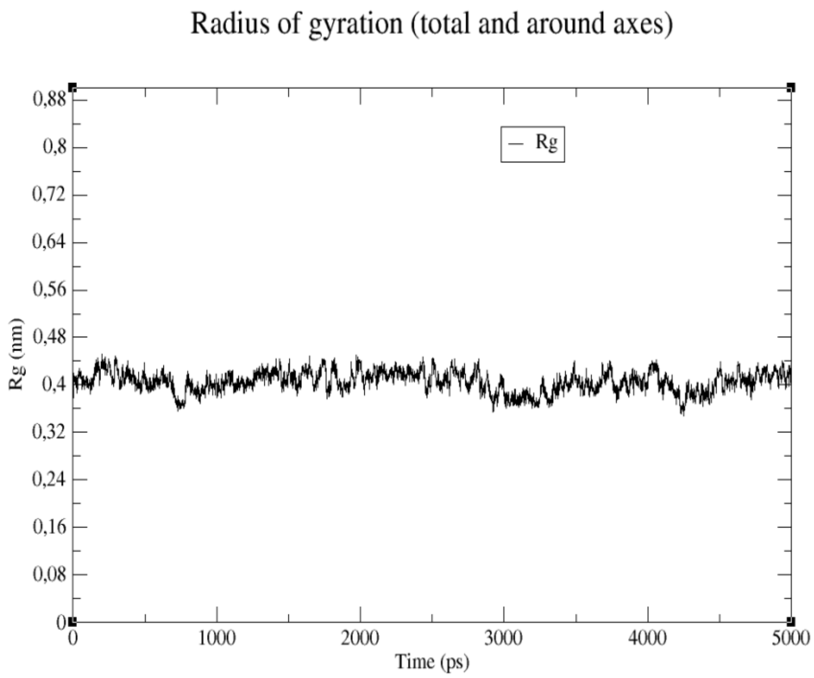

Figure 4: The Radius of gyration valuesof the water medium system of AHK tripeptide.

Molecular Docking and ADME Results

The docking analysis of AHK tripeptide onto a vascular endothelial growth factor receptor 2 (pdb code: 3VO3) was performed and the most possible binding energies were calculated at
-7.769 kcal / mol in **Fig. 5and Fig. 6**. In the active region of the protein in which the AHK tripeptide interacts with, the green, blue, dark blue and orange colored parts represent regions of hydrophobic, polar, positively charged and negatively charged amino acids, respectively in **Fig.7.** The strong hydrogen bonds formed resulted in the formation of stable binding poses between AHK tripeptide and protein. As shown in **Fig.7**. and **Fig.8,** the hydrogen bonds formed with LEU-37 (1,81 Å and 2.39 Å), LYS-117 (1.62 Å), CYS-116 (1.67 Å) and ASN-120 (1.79 Å and 2.18 Å) residues for vascular endothelial growth factor receptor 2. The electrostatic potential of the vascular endothelial growth factor receptor 2 and the docked pose of the AHK was shown in **Fig.9.** The ADME profile, in which the pharmacokinetic properties of AHK was determined by Qikprop tool of the Maestro software in **Table 1.** Pharmacokinetic parameters which are required for predicting the drug-like properties of molecules were defined based on Lipinski 5s rule. According to this rule; the molecular weight should not be greater than 500Mw, no more than 5 hydrogen bond donors, no more than 10 hydrogen bond acceptors, and the octanol / water partition coefficient should not be greater than 5. AHK tripeptide has 354 g/mol molecular weight, 6.5 hydrogen bond donors and 9.5 hydrogen bond acceptors, and the calculated value of octanol / water partition coefficient was-3.615. The rate of skin permeability (SP) is a very important pharmacokinetic property for the transdermal effect of drugs and cosmetics, especially in the fields of medicine and cosmetics. The calculated QP log Kp for skin permeability (Kp in cm/hr) value of AHK tripeptide was -9.743. It is also important to know the ability to cross the blood brain barrier. The calculated brain/blood partition coefficient (QPlogBB) is -2.635 and is within the recommended range of value (-3.0 – 1. 2).

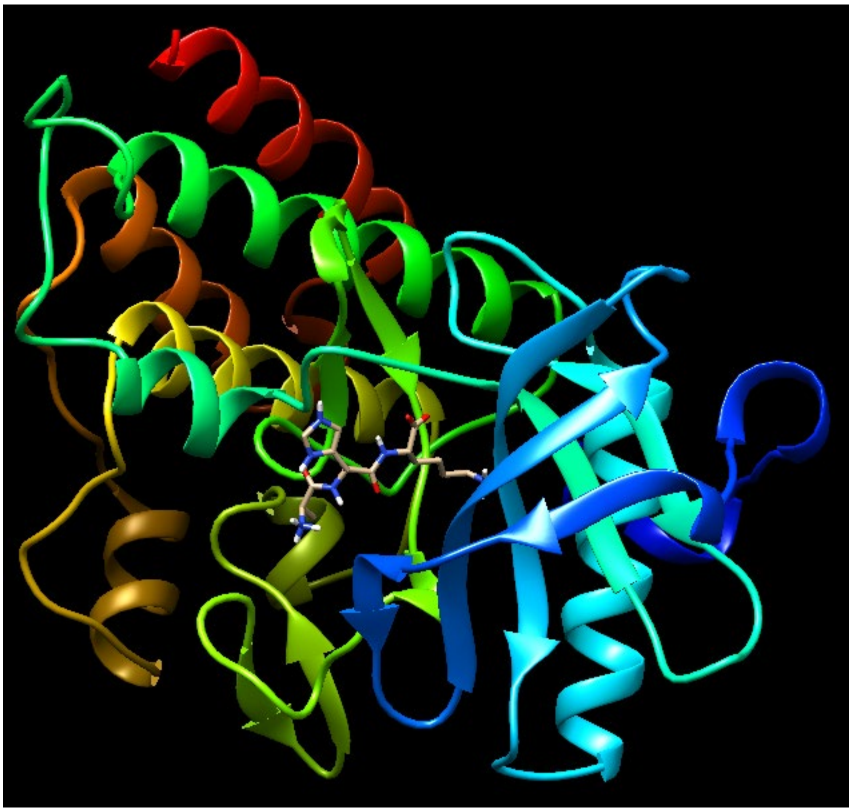

Figure 5: The binding poses between the active site of the vascular endothelial growth factor receptor 2 and AHK tripeptide.

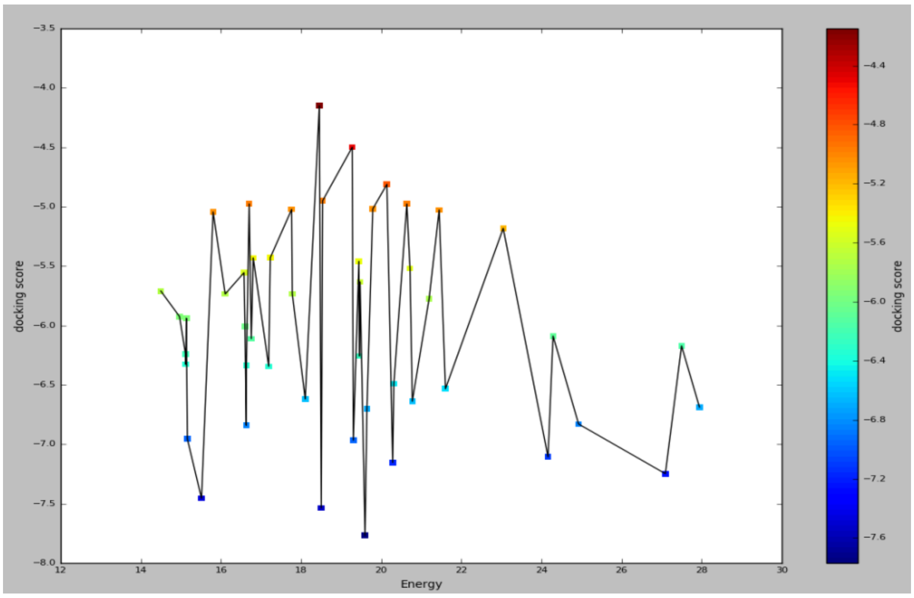

Figure 6: The possible docking score values and their energies between the vascular endothelial growth factor receptor 2 and AHK tripeptide.

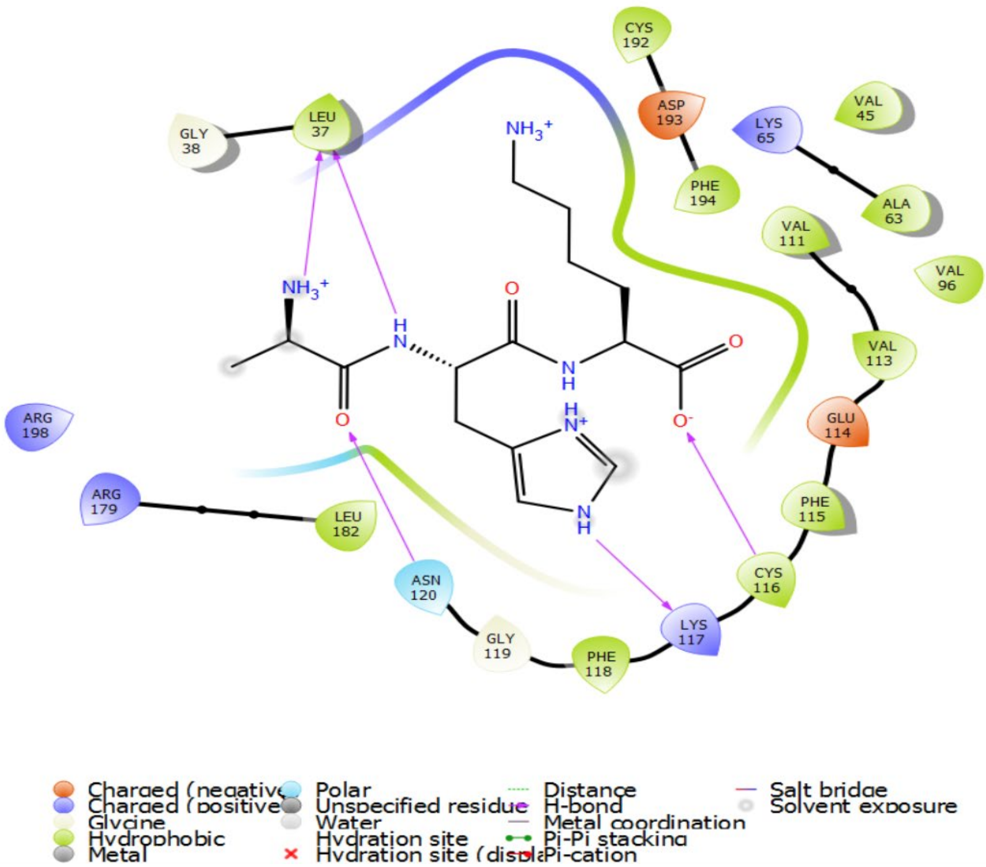

Figure 7: 2D ligand interaction of AHK tripeptide in the active side of the vascular endothelial growth factor receptor 2.

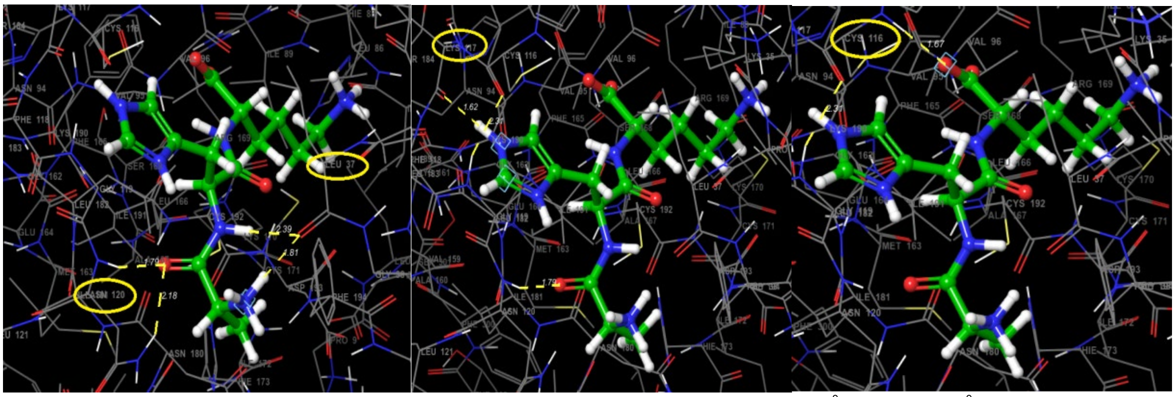

Figure 8: The hydrogen binding interactions of AHK with LEU-37 (1,81 Å and 2.39 Å), LYS-117 (1.62 Å), CYS-116 (1.67 Å) and ASN-120 (1.79 Å and 2.18 Å) residues for vascular endothelial growth factor receptor 2

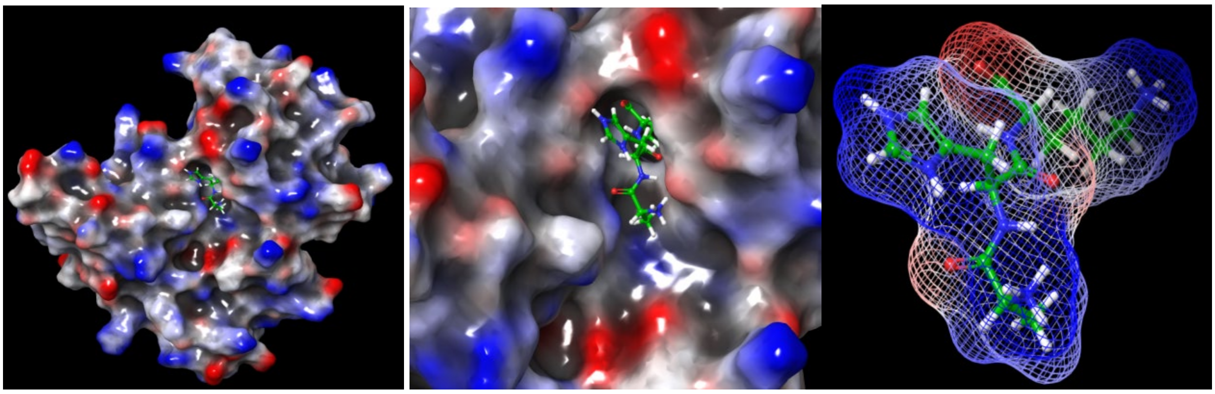

Figure 9: The electrostatic potential of the vascular endothelial growth factor receptor 2 and the docked pose of the AHK.

Table 1: The calculated ADME properties of AHK tripeptide.

Principal Descriptors:		***Values***	***Recommended Values***
Solute Molecular Weight	=	354.408	(130.0 / 725.0)
Solute Dipole Moment (D)	=	10.434	(1.0 / 12.5)
Solute Total SASA	=	680.653	(300.0 /1000.0)
Solute Hydrophobic SASA	=	284.204	(0.0 / 750.0)
Solute Hydrophilic SASA	=	307.16	(7.0 / 330.0)
Solute Carbon Pi SASA	=	89.289	(0.0 / 450.0)
Solute Weakly Polar SASA	=	0	(0.0 / 175.0)
Solute Molecular Volume (A^3)	=	1191.368	(500.0 /2000.0)
Solute vdW Polar SA (PSA)	=	195.19	(7.0 / 200.0)
Solute No. of Rotatable Bonds	=	13	(0.0 / 15.0)
Solute as Donor - Hydrogen Bonds	=	6.5	(0.0 / 6.0)*
Solute as Acceptor - Hydrogen Bonds	=	9.5	(2.0 / 20.0)
Solute Globularity (Sphere = 1)	=	0.798	(0.75 / 0.95)
Solute Ionization Potential (eV)	=	9.357	(7.9 / 10.5)
Solute Electron Affinity (eV)	=	-0.183	(-0.9 / 1.7)
Predictions for Properties:			
QP Polarizability (Angstroms^3)	=	34.030M	(13.0 / 70.0)
QP log P for hexadecane/gas	=	13.579M	(4.0 / 18.0)
QP log P for octanol/gas	=	27.160M	(8.0 / 35.0)
QP log P for water/gas	=	23.858M	(4.0 / 45.0)
QP log P for octanol/water	=	-3.615	(-2.0 / 6.5)*
QP log S for aqueous solubility	=	0.5	(-6.5 / 0.5)*
QP log S - conformation independent	=	0.548	(-6.5 / 0.5)
QP log K hsa Serum Protein Binding	=	-1.479	(-1.5 / 1.5)
QP log BB for brain/blood	=	-2.635	(-3.0 / 1.2)
No. of Primary Metabolites	=	8	(1.0 / 8.0)
Predicted CNS Activity (-- to ++)	=	--	
HERG K+ Channel Blockage: log IC50	=	-2.114	(concern below -5)

Apparent Caco-2 Permeability (nm/sec)	=	0	(<25 poor. >500 great)
Apparent MDCK Permeability (nm/sec)	=	0	(<25 poor. >500 great)
QP log Kp for skin permeability	=	-9.743	(Kp in cm/hr)
Jm. max transdermal transport rate	=	0	(micrograms/cm^2-hr)
Lipinski Rule of 5 Violations	=	1	(maximum is 4)
Jorgensen Rule of 3 Violations	=	2	(maximum is 3)
% Human Oral Absorption in GI (+-20%)	=	0	(<25% is poor)
Qual. Model for Human Oral Absorption	=	low	(>80% is high)

Conclusion

Along with its high antioxidant properties, AHK tripeptide is used in the treatment of hair loss and skin rashes, and it also has an important potential in cosmetics because it helps collagen production and increases dermal cell proliferation and viability. AHK tripeptide which has such important fields of application has been modeled for the first time using *in silico* methods, the most stable geometric structure has been determined, the conformational variations tripeptide in body conditions (water medium) has been examined and also the mechanism of interaction of AHK tripeptide with possible receptor that can effect in the body has been revealed. The discovery and development of peptide structures with a more active and improved mechanism of action is an active field of study, particularly in biochemistry and pharmacology and cosmetic. This study, which reveals the molecular structure, conformational change and mechanism of action of AHK tripeptide, is an original study.

Acknowledgements

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References

Bienert, S., Waterhouse, A., de Beer, T.A., Tauriello, G., Studer, G., Bordoli, L., et al., 2016, The SWISS-MODEL Repository—new features and functionality, *Nucleic acids research*, *45*(D1), D313-D9.

Bussi, G., Donadio, D., & Parrinello, M.,2007, Canonical sampling through velocity rescaling, *The Journal of chemical physics*, *126*(1), 014101.

Darden, T., York, D., & Pedersen, L., 1993, Particle mesh Ewald: An N. log (N) method for Ewald sums in large systems, *The Journal of chemical physics*, *98*(12), 10089-10092.

Friesner, R.A.,Murphy, R.B., Repasky, M.P., Frye, L.L., Greenwood, J.R., Halgren, T.A., et al., 2006, Extra precision glide: Docking and scoring incorporating a model of hydrophobic enclosure for protein− ligand complexes, *Journal of medicinal chemistry*, *49*(21), 6177-96.

Friesner, R.A., Banks, J.L., Murphy, R.B., Halgren, T.A., Klicic, J.J., Mainz, D.T., et al., 2004, Glide: a new approach for rapid, accurate docking and scoring. 1. Method and assessment of docking accuracy, *Journal of medicinal chemistry*, *47*(7), 1739-49.

Frisch, M., Trucks, G., Schlegel, H., Scuseria, G., Robb, M., Cheeseman, J., Scalmani, G., Barone, V., Mennucci, B., Petersson, G., Gaussian 09, revision a. 02, gaussian. Inc., Wallingford, CT 2009;200.

Halgren, T. A., Murphy, R. B., Friesner, R. A., Beard, H. S., Frye, L. L., Pollard, W. T., & Banks, J. L. (2004). Glide: a new approach for rapid, accurate docking and scoring. 2. Enrichment factors in database screening. *Journal of medicinal chemistry*, *47*(7), 1750-1759.

Harder, E., Damm, W., Maple, J., Wu, C., Reboul, M., Xiang, J.Y., et al., 2015, OPLS3: a force field providing broad coverage of drug-like small molecules and proteins, *Journal of chemical theory and computation*,*12*(1):281-96.

Hess, B., Bekker, H., Berendsen, H. J., & Fraaije, J. G., 1997, LINCS: a linear constraint solver for molecular simulations, *Journal of computational chemistry*, *18*(12), 1463-1472.

Humphrey, W., Dalke, A., & Schulten, K., 1996, VMD: visual molecular dynamics, *Journal of molecular graphics*, *14*(1), 33-38.doi: 10.1016/0263-7855(96)00018-5.

Jung, J. I., Park, K. Y., Lee, Y., Park, M., & Kim, J. (2018). Vitamin C-linker–conjugated tripeptide AHK stimulates BMP-2-induced osteogenic differentiation of mouse myoblast C2C12 cells. Differentiation, 101, 1-7.

Miyamoto, N., Sakai, N., Hirayama, T., Miwa, K., Oguro, Y., Oki, H., ... & Yamasaki, S. (2013). Discovery of N-[5-({2-[(cyclopropylcarbonyl) amino] imidazo [1, 2-b] pyridazin-6-yl} oxy)-2-methylphenyl]-1, 3-dimethyl-1H-pyrazole-5-carboxamide (TAK-593), a highly potent VEGFR2 kinase inhibitor. *Bioorganic & medicinal chemistry*, *21*(8), 2333-2345.

Ntie-Kang, F., Lifongo, L. L., Mbah, J. A., Owono, L. C. O., Megnassan, E., Mbaze, L. M. A., ... & Efange, S. M. (2013). In silico drug metabolism and pharmacokinetic profiles of natural products from medicinal plants in the Congo basin. *In silico pharmacology*, *1*(1), 12.

Parrinello, M., & Rahman, A., 1981, Polymorphic transitions in single crystals: A new molecular dynamics method, *Journal of Applied physics*, *52*(12), 7182-7190.

Patt, L. M., & Procyte, A. (2009). Neova® Advanced Essential Eyelash™ Conditioner Renews Health and Restores Vitality to Natural Lashes. skin, 1, 2.

Patt, L. M., & Procyte, A. (2010). Neova® Refining Eye Lift Reduces the Appearance of Periorbital Wrinkles with DNA Repair and Copper Peptide Technologies. skin, 1, 2.

Pyo, H. K., Yoo, H. G., Won, C. H., Lee, S. H., Kang, Y. J., Eun, H. C., ... & Kim, K. H. (2007). The effect of tripeptide-copper complex on human hair growth in vitro. Archives of pharmacal research, 30(7), 834-839.

Rushton, D. H. (2002). Nutritional factors and hair loss. Clinical and Experimental Dermatology: Clinical dermatology, 27(5), 396-404.

Sastry, G.M., Adzhigirey, M., Day, T., Annabhimoju, R., Sherman, W., 2013, Protein and ligand preparation: parameters, protocols, and influence on virtual screening enrichments, *Journal of computer-aided molecular design*, *27*(3):221-34.

Shimura, H., Tanaka, R., Shimada, Y., Yamashiro, K., Hattori, N., & Urabe, T. (2017). Glycyl-alanyl-histidine protects PC12 cells against hydrogen peroxide toxicity. BMC biochemistry, 18(1), 14.

Smith, P. E. & van Gunsteren, W. F.,1993, The viscosity of SPC and SPC/E water at 277 and 300 K, *Chemical physics letters*, *215*(4), 315-318.

Søndergaard, C. R., Olsson, M. H., Rostkowski, M., & Jensen, J. H. (2011). Improved treatment of ligands and coupling effects in empirical calculation and rationalization of p K a values. *Journal of chemical theory and computation*, *7*(7), 2284-2295.

Van Der Spoel, D., Lindahl, E., Hess, B., Groenhof, G., Mark, A. E., Berendsen, H. J.,2005, *Journal of computational chemistry*, *26*(16), 1701-1718.

van Gunsteren, W. F.; Billeter, S. R.; Eising, A. A., Hünenberger, P. H., Krüger, P., Mark, A. E., Scott, W. R., Tironi, I. G., 1996,*Biomolecular simulation: The {GROMOS96} manual and user guide*.

Verlet, L., 1967, Computer "experiments" on classical fluids. I. Thermodynamical properties of Lennard-Jones molecules, *Physical review*, *159*(1), 98.

PLATFORM TO REQUIRE MEDICAL HEALTHCARE ABOARD DOURO CRUISES

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Abstract: Cruise tourism in the Douro is ever growing and ensuring the health and well-being of the tourists should be a priority amongst the organizers of the trips. After a cross-sectional field study, consisting on applying a survey during the cruise trips, was undertaken by the research team, it was shown that the majority of the participants were receptive to the idea of a mobile application to facilitate the requisition of specific medical care, before the trips. The research team then started developing a platform, consisting of the application mentioned above, a back-office website, and a shared database. The app is being built on android studio, utilizing its native programming language, java. The website is being developed on visual studio, using the ASP.NET framework. The database is built on SQL Server 2014, and will be deployed to a server to interact with both the application and the website. The client interacts with the app to request medical care aboard the cruise ship. The request will be submitted into the database and must then be validated by an admin through the website, although this is only necessary for requests that require the submission of a prescription.

Keywords: Mobile application; Tourists; Health care

Introduction

Tourism is constantly and consistently growing in Portugal. In 2016 alone, a total of 28,4 million international tourists visited Portugal (INE, 2017). The Douro region is one of the oldest in the country, having been named a UNESCO World Heritage in 2001.
One of the most important part of the region in regard to tourism is the Douro River, which is navigable, and its surrounding landscape (Sousa, Monte &Fernandes, 2013).
Mobile apps have been increasing in number in the health sector, either for specific diseases and conditions, medical providers, medical education, and even geared for the general public, although these apps are usually much less complex. Although most of them are related to weight loss, they can still be used for other areas, such as tourism (Boulos, Brewer, Karimkhani, Buller & Dellavalle, 2014).
The health and well-being of tourists who frequent river cruises on the Douro River should be a premise of vessels that perform such cruises (Guy, Henson & Dotson, 2015; Kim, Woo & Uysal, 2015).
If tourists who want to take cruises, can at the time of booking, request various health services according to their needs, utilizing a mobile application, there is no doubt that we will be contributing to the health promotion of tourists who visit the Douro region (Ker-Cheng et all, 2014).
After a field study realized by the research team, which involved a survey with questions about the opinion of users about the need for such an application, the conclusion was that the great majority (76,0% of all tourists) saw the application as something they would be favorable towards.
And, if so, this project is being developed and one of the objectives has to do with the development of a mobile application.

Materials and Methods

The platform is being developed by the research team. It will consist of a mobile app, a back-office website, and a shared database. Each of these elements require different platforms and technologies.
The app is being built on android studio. This creation kit is widely used for various types of apps, due to its existing support, consistent updates, and functions like the gradle system, an automation system that supports multi-project code builds. It is the most popular tool for android app design, making it a tool that has lots of technical support and simplicity of use (Arquitetura da plataforma|Android Developers, s.d.).
It utilizes an oauth2.0 protocol for user authentication. This protocol allows a certain website or app to access their information on other websites, without the need for password sharing (OAuth 2.0 - OAuth). The programming language utilized was java, the native coding language of the Android Studio kit, making it a simple and obvious choice. It has a built in json converter to read data received from the database, and to upload any changes.
The database is being developed on the SQL Server 2014 platform, and will be hosted on a server, to be accessed by both the website and the app. This platform allows the storing and treatment of data, while also allowing other applications like websites and mobile apps to have access to said data. The broad array of support for all kinds of software that require a database server, and the streamlined interface of the server, make it a good choice for a database support tool (Otey, 2014)
The website was built upon the Visual Studio programming platform, using the asp.net language and the bootstrap framework. Visual Studio was selected for its vast array of features, as well as being a familiar environment for the developers. Asp.net was chosen due to its scalability and speed (Visual Studio 2019 | Visual Studio), and due to it being familiar to the research team. Bootstrap was chosen due to its organisational ability, and the responsiveness it brings to the website (Bootstrap. the most popular HTML, CSS, and JS library in the world.) and its simplicity and easiness of use. Its purpose is to simply be a back-office platform.
All the elements of the platform will interact with each other. The app will receive information regarding the trips from the database, and, after the user confirms a request, it will be sent to the database, which will in turn send it to the website for validation. After the request is validated, the database state of the request will be altered. It is also possible for the user to cancel requests, which will be an immediate action and will require no validation from the website.

Results and Discussion

Initial testing of the app was mainly positive, although it was done in a local environment, with the database not being hosted on a server. Further tests will be completed with a fully online platform.

Front end users:

The user will be required to log in, utilizing the oauth2.0 protocol. From there, he can access all the features of the app. The login screen is as follows, see (Figure 1).
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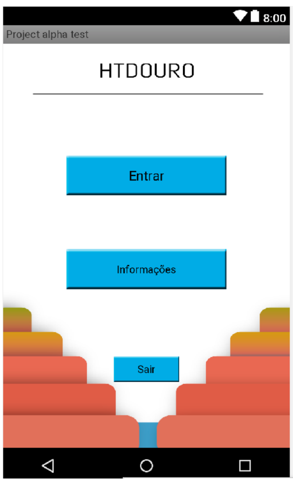

Figure 1 - Login Screen

Figure 2 - Home Page

This will take the user to the home page, where the user can view trips already linked, add new trips, or consult the contacts & information page, see (Figure 2).

On the trip list, the user can select from a list of trips linked (it's assumed that in most cases there will be a single trip), see (Figure 3).

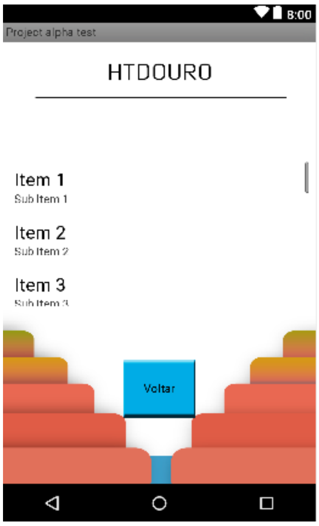

Figure 3 - Trip List

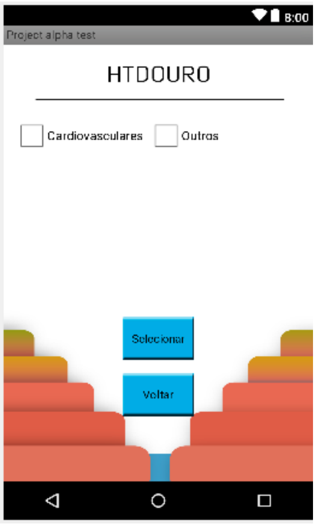

Figure 4 - Health Care Requirement Screen

The user then selects a trip, and can view its info, as well as select the option to request medical care.
The user can then select from a list of offered medical care packages (some of them will require that a prescription be sent by email to an admin at a later date), see (Figure 4).

To link a new trip, the user must request a trip token when purchasing the ticket. Every ticket can only have 1 code, and every code can only link to 1 trip. The user will then enter the code in the respective field, and the trip will be linked to the active account. It is possible to request medical care for friends or family using the same account, as long as the user has the required codes for every ticket.
On the contacts and info page, the user will be able to learn a bit more about the company organizing the trip, see (Figure 5).

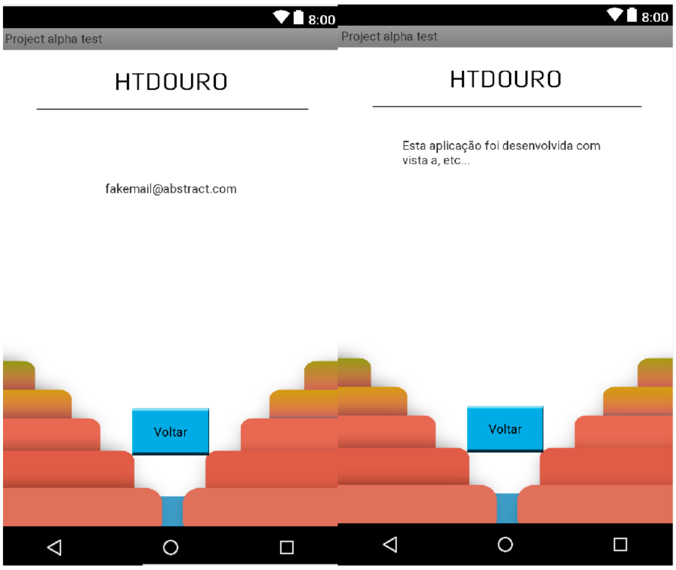

Figure 5 - Contacts and information screens

Back End Users:

Only the admins will interact with the website. The admins will receive a username and password from the database manager. The login function of the website is a more classical approach than the application. It simply requires the input of the username and password given to the admin, see (Figure 6).

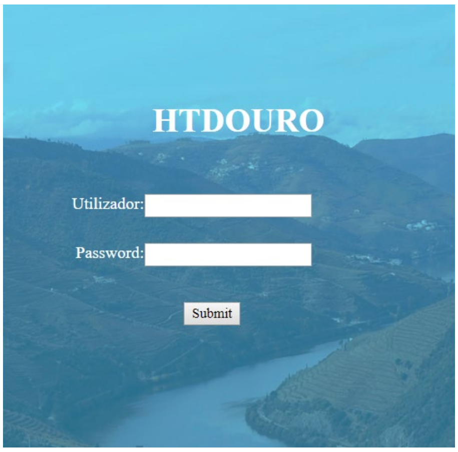

Figure 6 - Website's Login Page

Figure 7 - Website's Trip List Page

The admin will be taken to the home page after the login. Here, one can select from a list of trips from the company the admin belongs to, see (Figure 7).

Afterwards, the admin will view the trip page, where he can access the trip's information, and a list of passengers whom require medical care, see (Figure 8).

Figure 8 - Website's Trip Info Page

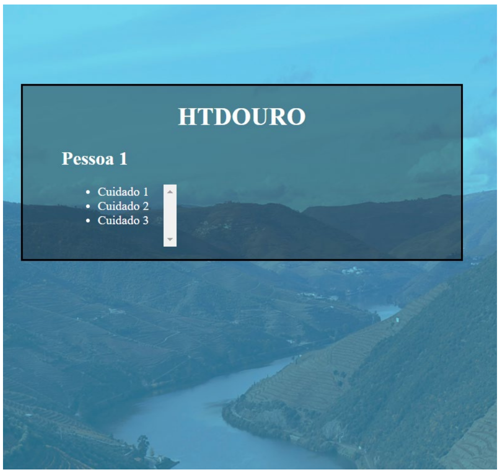

Figure 9 - Website's Health Care Requirements Page

He can then access the specific health care requirements of each passenger on the list. Here the admin will have the option to validate requirements, see (Figure 9).

The admin can also access the contacts and information page, see (Figure 10).

Figure 10 - Contacts and Information Pages

Conclusion

Technology application in healthcare has been arousing engineering's attention for a long time in support to health recovery and maintenance therapy practices.

In this regard, creating support systems to watch the fulfilling of the therapeutical plan, assisting healthcare professionals and informal caregivers on dependent elders' care may be an added value.

Acknowledgements

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References

Arquitetura da plataforma | Android Developers. (s.d.) Retrieved from https://developer.android.com/guide/platform

Booststrap. the most popular HTML, CSS, and JS library in the world. (s.d). Retrieved from https://getbootstrap.com/

Boulos, M, Brewer, A, Karimkhani, C, Buller, D & Dellavalle, R (2014) Mobile medical and health apps: state of the art, concerns, regulatory control and certification. Online Journal of public health informatics, 5(3):1-23. DOI: 10.5210/ojphi.v5i3.4814

Guy, B.; Henson, J. & Dotson, M. (2015). Characteristics of consumers likely and unlikely to participate in medical tourism. International Journal of Healthcare Management, 8(2), 68-76. DOI: 10.1179/2047971914Y.0000000076

Instituto Nacional de Estatística (2017). Turismo Internacional 2016. Serviço de Comunicação e Imagem. Instituto Nacional de Estatística, Lisboa.

Ker-Cheng, L., Lin-Sheng, C., Chien-Ming T., Hsuan-Hung L., Yung-Fu C. & Chien-Lei C. (2014). A Smartphone APP for Health and Tourism Promotion. Mathematical Problems in Engineering. Hindawi Publishing Corporation, 1-10. DOI: 10.1155/2014/583179

Kim, H., Woo, E. & Uysal, M. (2015). Tourism Experience and Quality of Life Among Elderly Tourists. Tourism Management, 46, 465-476. DOI: 10.1016/j.tourman.2014.08.002

OAuth 2.0 – OAuth (s. d). Retrieved from https://oauth.net/2

Otey, M. (2014, March) Top 10: New features in SQL Server 2014. Retrieved from https://www.itprotoday.com/sql-server/top-ten-new-features-sql-server-2014

Sousa, C., Monte, A., & Fernandes, P. (2013) - Impacto no turismo da região demarcada do Alto Douro vinhateiro, após a classificação de Património Mundial da Humanidade pela Unesco. In III Congresso Internacional de Turismo da ESG/IPCA. ESG/IPCA, Barcelos, 261-289.

Visual Studio 2019 | Visual Studio (s.d.). Retrieved from https://visualstudio.microsoft.com/vs//

USING VIDEO-ANALYSIS OF MOTIONS IN PHYSICS TEACHING AND LEARNING

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Abstract: This paper describes using video-analysis based tasks in the educational process of the students at the technical university. The attention is paid to university students and their knowledge of physics and conception/misconception.
The role of students in video analysis is to realize necessary physical characteristics, to choose a suitable way to a problem solution and from the relations among physical quantities to find a solution to a task. The tasks can be considered being the problem-solving tasks with a well-defined problem and according to Bloom´s taxonomy of cognitive domain they require higher level solution – mostly application, analysis and synthesis. On the other hand, it is also possible to demonstrate students, by a simple mathematical analysis, the use of integrals and derivatives in physics.
Using the method of video-analysis by interactive program Tracker the level of knowledge of students can be increased and some misconceptions can be eliminated.
Keywords: STEM education, FCI test, program Tracker

Introduction

We have already presented students' understanding of the real physical processes in previous works that is not correct (Hockicko et al, 2013). Many authors confirmed that during the last decades, entry-level engineering students' basic abilities in Physics (and Mathematics) have decreased dramatically (Pinxten et al, 2017). Physics are often considered to be difficult subjects. The fundamental laws are expressed in the language of mathematics. Teachers constantly work on improving students´ understanding of various phenomena and fundamental laws. One of the creative methods of teaching physics which makes natural sciences more interesting for students is video-analysis (VAS method) using the program Tracker. Collaborative projects based on digital video-analysis provide an educational, motivating and cost-effective alternative to traditional course-related activities in introductory physics (Laws et al, 1998).

The traditional teaching of Newtonian mechanics in the early years of university studies eliminates the wrong perception of students acquired during their secondary school studies only to a small extent. It was also shown that traditional lectures help to acquire only basic knowledge without deeper understanding and the ability of problem solving; students do not show conceptual understanding of the subject which should result from a sufficient number of solved quantitative tasks and from logically clear lectures (Redish, 2003).

This led us to producing a video set, by means of which we explained physical laws in lectures and realized video-analysis in seminars (Hockicko, 2013). The tasks can be considered being the problem-solving tasks with a well-defined problem and according to Bloom´s taxonomy of cognitive domain they require higher level solution – mostly an application, an analysis and a synthesis. Many tasks based on video-analysis are suitable to demonstrate a simple mathematical analysis, the use of integrals and derivatives in physics. The use of tasks based on video-analysis in physics can significantly affect the differences in knowledge when students solving traditional tasks from printed textbook (Hockicko et al, 2015).

We try to prepare our students for teamwork and collaboration with scientists and engineers, so they can work in interdisciplinary fields at the interface between Physics and technical departments. As a result, we consider theoretical training not as the goal but to an end, and therefore it should always be followed by practical application.

It is very important to use the multimedia tools also in other subjects including basic education to make science and technology more appealing and to address the scientific apathy crisis of young people (Bussei, 2003). Game provides many examples that can bring physics to life in the classroom. Especially, the kinematic and dynamic characteristics of motions are worth a physics classroom discussion. It enables the students to work in much the same way as sport scientists do (Heck 2010). Therefore, we decided to support freshmen by interactive lectures using video and video analysis and find out whether interactive lectures are more effective in increasing students prior knowledge level of Physics than traditional lectures.

Methodology of teaching physics

Using the program Tracker students can detect the relationship between physical quantities and describe a motion using time dependencies. Tracker offers time dependencies of 22 physical quantities (+ we can define other), data processing by means of graphs and tables. From the number of frames per second (30 fps or 120 fps usually) the time is deduced ($\Delta t = 0.033$ s or $\Delta t = 0.0083$ s) while the position can be measured in two dimensions (x, y) using a video image after calibration. The function autotracking in this program allows for accurate tracking without mouse. The studied motion can be divided into two parts: the horizontal component and the vertical component. These two components can be analysed independently of each other and afterwards the results can be combined to describe the total motion ($x(t)$, $y(t)$, $v_x(t)$, $v_y(t)$, $a_x(t)$, $a_y(t)$).

The students can fit the time dependencies of position, velocity, acceleration and other using a data tool which provides a data analysis including automatic or manual curve fitting of all or any selected subset of data. The position and the velocity can be plotted and fitted to see the correlation between the real data and the kinematic equations. For example, students have found that the trajectory of the free fall ball is always a parabola (Hockicko 2011).

The example of the task for students:

The cylinders with different mass are rolling down an incline that is placed at a certain height above ground. What will be the horizontal distances of the points at which the cylinders hit the ground from the end of the incline? (Length of the black square segment: 1 cm, frequency of taking pictures: 120 fps, masses of cylinders: m1 = 1.807 kg, m2 = 0.640 kg, m3 = 0.264 kg)

The solution using video-analysis using program Tracker:

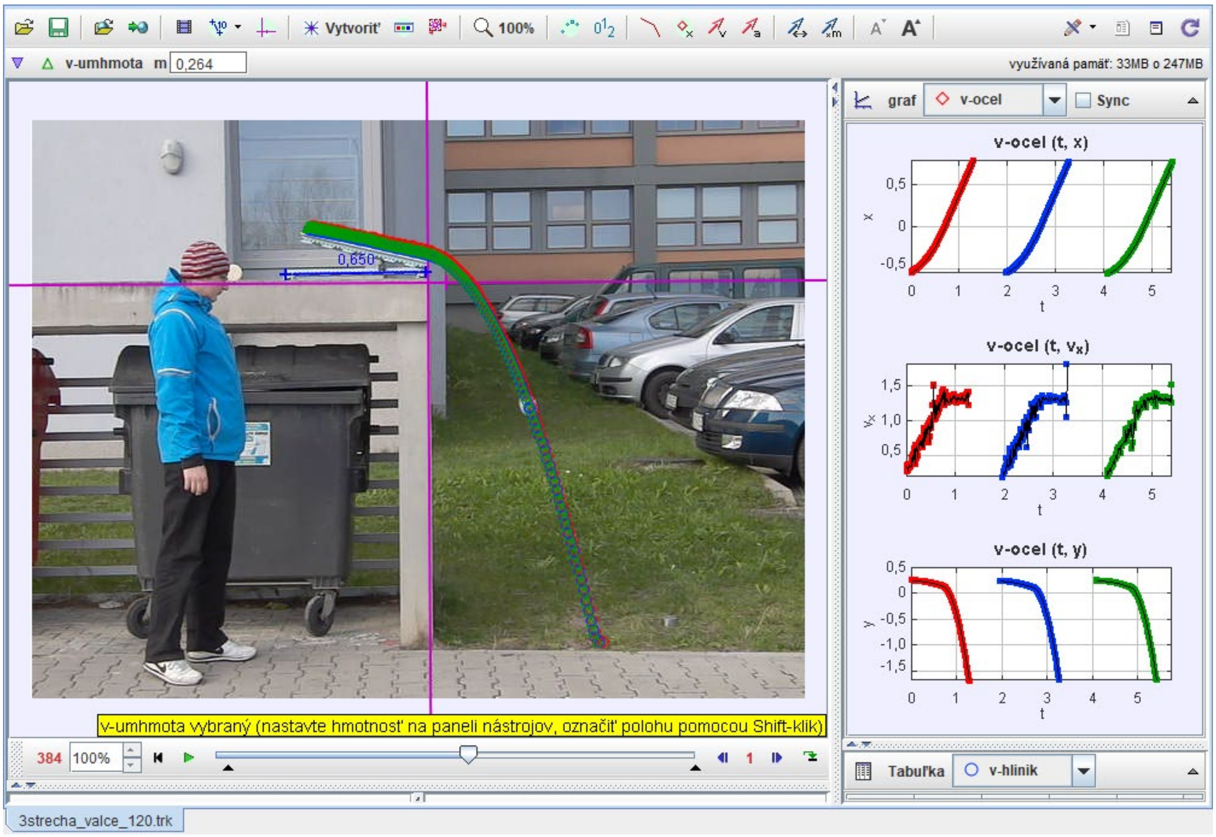

Figure 1. The analysis of motion using program Tracker. Red – a metal cylinder, blue – aluminium, green – plastic.

The next task: *Compare the motions of cylinders with different mass and the same diameter. If they all start moving from rest at the same elevation and roll down without slipping, which of them reaches the bottom as the first? Which reaches it as the last? Try to compare the velocities at the end of an incline.*

Using Data Tool in Tracker which provided a data analysis including automatic or manual curve fitting of all or any selected subset of data, the students can fit the time dependencies of the position, velocity (Fig. 1), acceleration and other. The position and the velocity can be plotted and fitted to see the correlation between motions of different cylinders. Using the fit function, the students can find that all cylinders are rolling down an incline with basically the same acceleration and velocity of their centres of mass. For the students during the lecture and watching the video these results were quite interesting since both the speed and the acceleration of the centre of mass of the cylinder were independent of their mass.

Using this video (http://hockicko.uniza.sk/Priklady/video/strecha_valce_120.avi), we can change the misconception that *"heavier objects fall faster"* and show that the time of free fall does not depend on mass of body. We can analyse velocity and the position of cylinders in x-direction and show that the results do not depend on mass of cylinders in rolling motion, too.

Methodology of Evaluating

At the beginning of the second semester of academic year 2018/19, the Force Concept Inventory (FCI) (Hestenes el al., 1992) was administered to students at the Faculty of Electrical Engineering and Information Technology (FEEIT) University of Žilina (UNIZA) to find out their prior knowledge level of Physics. The pre-test was carried out at the beginning of the second semester during the first week, post-test was carried out at the end of the semester (the 13th week, after the semester course 'Physics') and it was attended by 64 students who participated in the both pre- and post-test.

The students were assigned to two groups – the experimental (attended by 44 students) and the control group (attended by 20 students). Only those students who participated actively in the lectures took part in the experimental group. Students who did not attend lectures took part in control group.

The lectures were conducted in an interactive way aimed at clarity - using real-life videos related to the topic. All videos were analysed with the help of the program Tracker (using VAS method). Students from both groups attended compulsory computational Physics seminars. The subject 'Physics' consists of 3 - 2 - 1 (lectures - exercises - labs) lessons per week, presence study. The semester consists of 13 weeks. The only difference between the experimental and the control group was that students from experimental group actively attended 13 interactive lectures while students from control group did not attend lectures.

Results and Discussion

These results (Fig. 2, Tab. 1) indicate that there is no statistical difference in the mean pre-test FCI score between the experimental and the control group at the beginning of the semester.

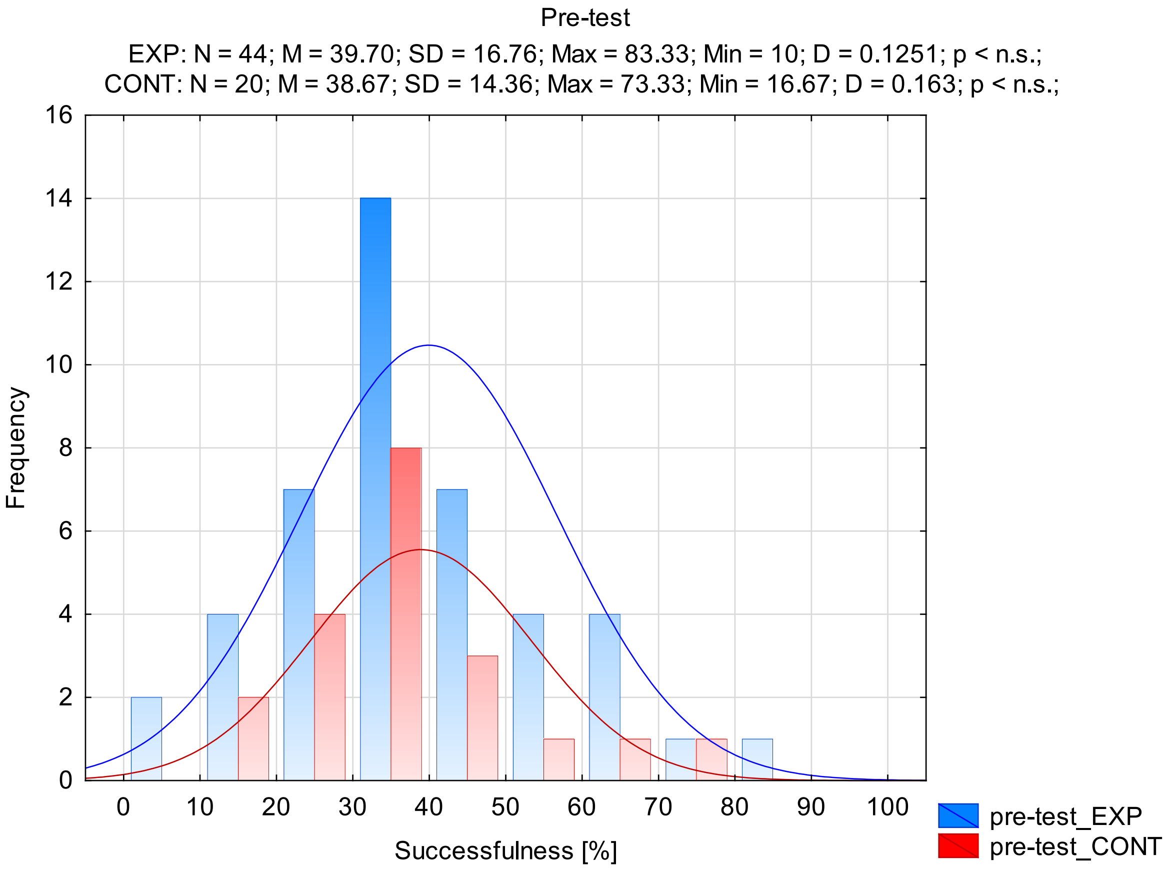

Figure 2. FCI score of pre-tests for the experimental and the control groups.

Table 1: Pre-test: F-Test Two Sample for Variances and t-Test: Two Sample Assuming Equal Variances.

	Experimental group	Control group
Mean	39.70	38.67
Variance	281.04	206.32
Observations	44	20
df	43	19
F	1.36	
P(F<=f) one-tail	0.24	
F Critical one-tail	2.02	
Pooled Variance	258.14	
Hypothesized Mean Difference	0	
df	62	
t Stat	0.24	
P(T<=t) one-tail	0.41	
t Critical one-tail	1.67	
P(T<=t) two-tail	0.81	
t Critical two-tail	2.00	

But results in Fig. 3 and Tab. 2 indicate that there is a statistical difference in the mean post-test FCI score of the experimental and the control group at the end of the semester.

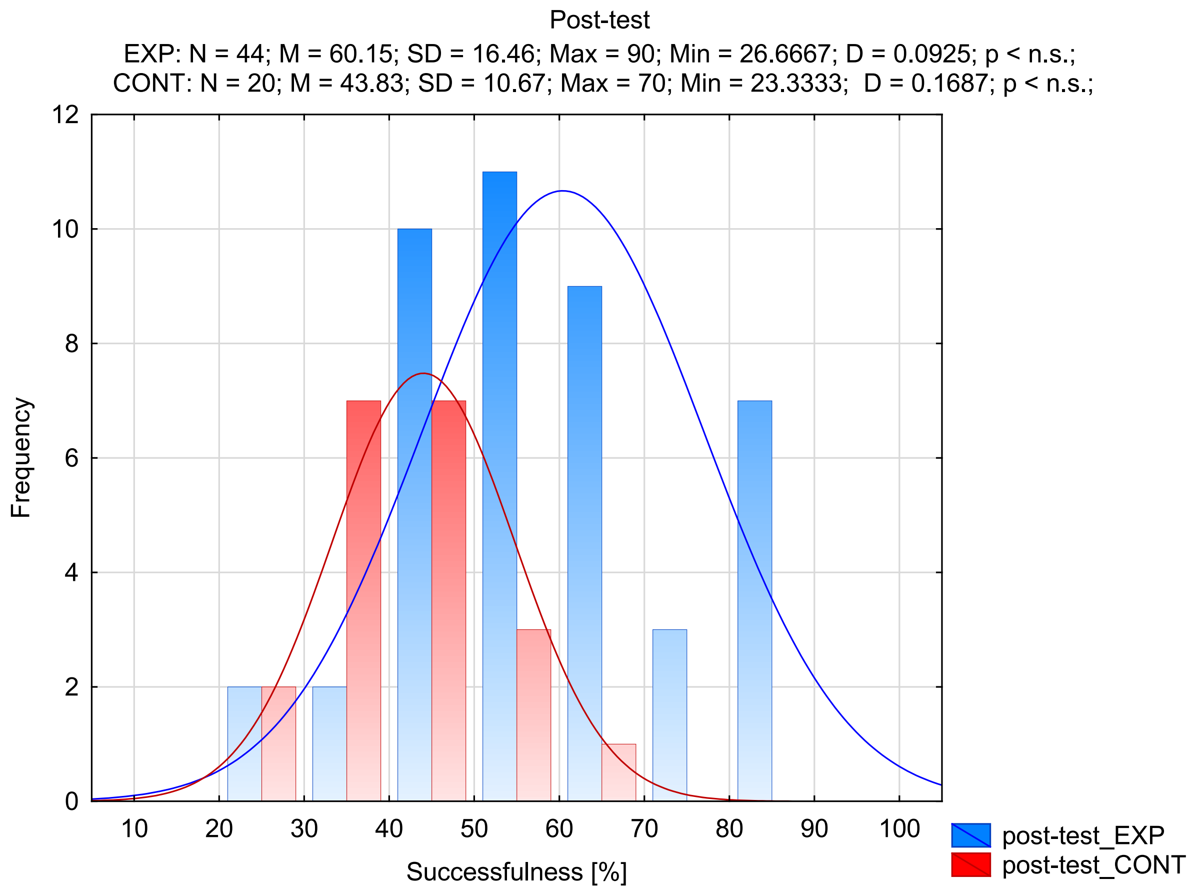

Figure 3. FCI score of post-tests for the experimental and the control groups.

Table 2: Post-test: F-Test Two Sample for Variances and t-Test: Two Sample Assuming Unequal Variances.

	Experimental group	Control group
Mean	60.15	43.83
Variance	270.78	113.77
Observations	44	20
df	43	19
F	2.38	
P(F<=f) one-tail	0.02	
F Critical one-tail	2.02	
Hypothesized Mean Difference	0	
df	54	
t Stat	4.74	
P(T<=t) one-tail	7.94E-06	
t Critical one-tail	1.67	
P(T<=t) two-tail	1.59E-05	
t Critical two-tail	2.00	

After that analysis we try to use Student t-test and compare pre and post-test results of experimental and control groups (Fig. 4, 5).

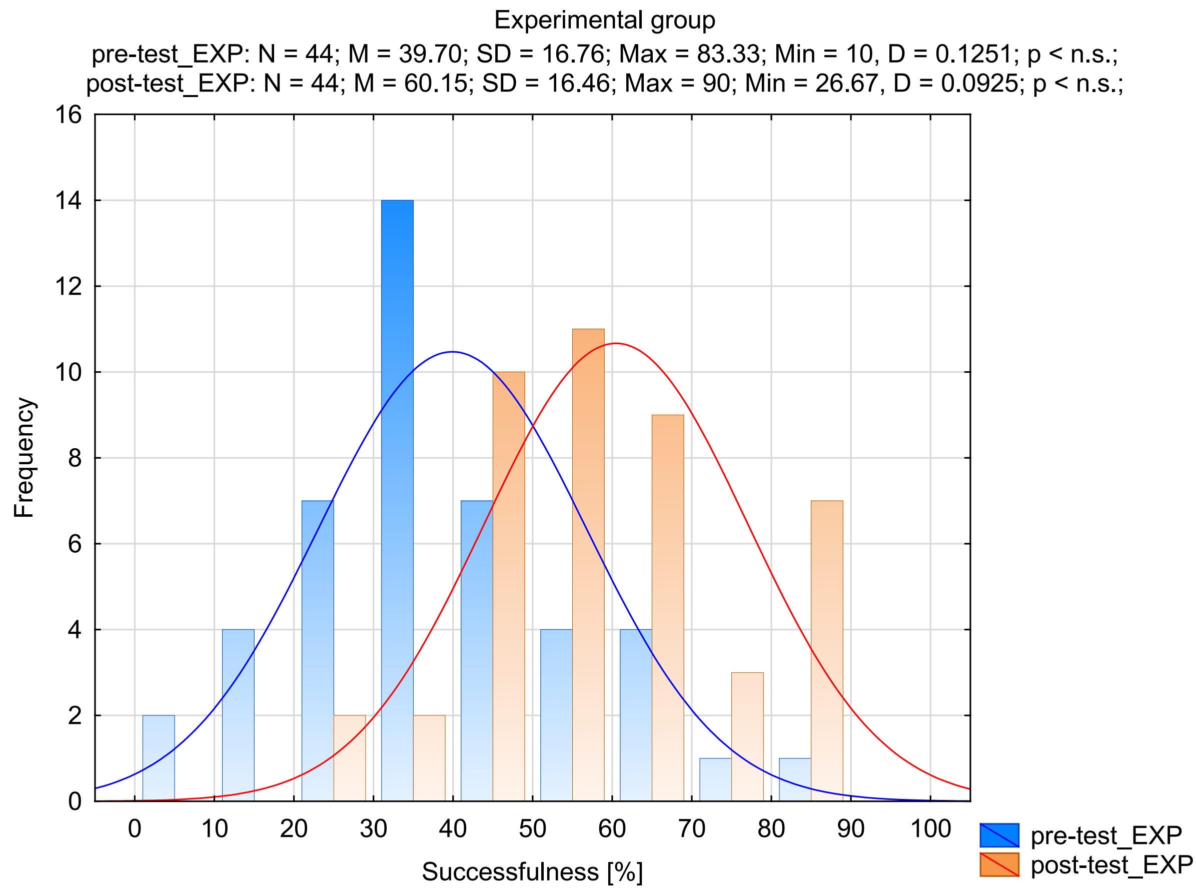

Figure 4. FCI score of pre and post-test for the experimental group.

Table 3: t-Test: Paired Two Sample for Means – Experimental group.

	Post-test	Pre-test
Mean	60.15	39.70
Variance	270.78	281.04
Observations	44	44
Pearson Correlation	0.53	
Hypothesized Mean Difference	0	
df	43	
t Stat	8.45	
P(T<=t) one-tail	5.47E-11	
t Critical one-tail	1.68	
P(T<=t) two-tail	1.09E-10	
t Critical two-tail	2.02	

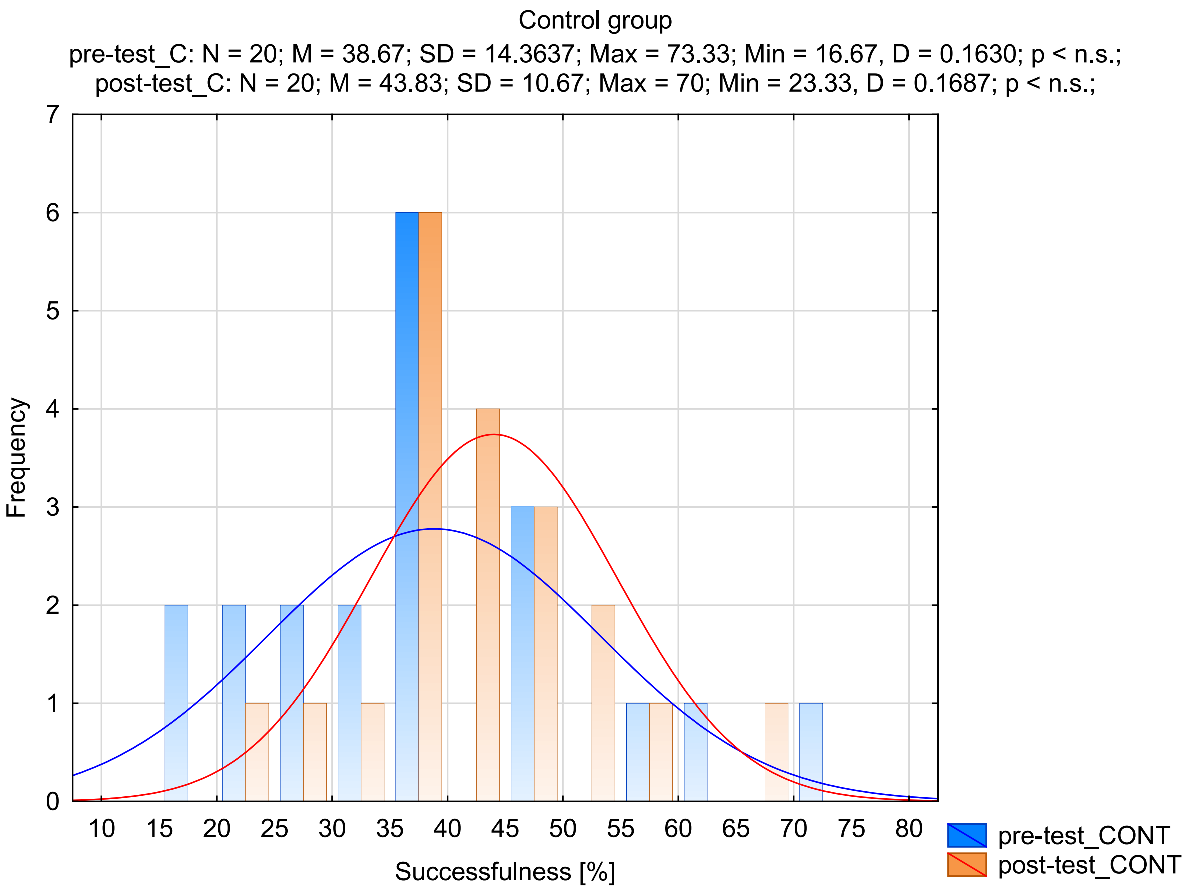

Figure 5. FCI score of pre and post-test for the control group.

Table 4: t-Test: Paired Two Sample for Means – Control group.

	Post-test	Pre-test
Mean	43.83	38.67
Variance	113.77	206.32
Observations	20	20
Pearson Correlation	0.83	
Hypothesized Mean Difference	0	
df	19	
t Stat	2.87	
P(T<=t) one-tail	0.0049	
t Critical one-tail	1.73	
P(T<=t) two-tail	0.0098	
t Critical two-tail	2.09	

The evaluation of pre-test and post-test of the experimental group at the beginning and at the end of semester (Fig. 4, Tab. 3) confirmed statistically significant difference between mean at the beginning and end of semester ($p < 0.001$).

The evaluation of pre-test and post-test score of the control group at the beginning and at the end of semester (Fig. 5, Tab. 4) confirmed statistically significant difference between mean at the beginning and end of semester, too, ($p < 0.005$) but p-value is lower in the case of the experimental group.

Discussion

We used Force Concept Inventory (FCI) test to verify students' knowledge of Physics (Kinematics and Dynamics). FCI test contained 30 qualitative multiple-choice tasks that focused on conceptual understanding of Newtonian mechanics (Hestenes et al., 1992).

As the authors of FCI test claim (Hestenes et al., 1992) it is necessary to point out that 60% of FCI test, for empirical reasons, is minimal threshold so that a student could continue in understanding Newtonian mechanics effectively. Below this threshold, a student's grasp of Newtonian concepts is insufficient for effective problem solving. Otherwise a student is not able to overcome difficulties which caused him/her misconception and thus s/he learns physics by heart. 80 – 85% FCI score represents the mastery level when a student thinks in terms of intentions and Newtonian physics. As the authors state such an outcome does not depend on what teacher, in what country and what kind of school s/he teaches. The results of pre-test (Fig. 2) reveal that only 14% of students in the experimental and 9% in control group reached the level of 60% or higher from FCI score.

In post-test (Fig. 3) the results reveal that 44% of students in the experimental and only 18% in control group reached the level of 60% or higher from FCI score. 16% of students in experimental group reached the mastery level from FCI score in post-test.

We also try to compare the pre-test results of students from other Slovak and foreign universities. Other research results using FCI tests reveal that the input knowledge level of UNIZA students concerning force, mass point kinematics and dynamics is at lower level in comparison with the students from university from Finland (Tampere University of Applied Sciences (TAMK)) (Mean(UNIZA) = 23 %, Mean(TAMK) = 45 % in academic year 2014/15) (Hockicko et al., 2015). There is also statistically significant difference between the average pre-test FCI score of the students in Slovakia and Russia (UNIZA and RSREU) at the beginning of the winter term 2018/2019 (Mean (UNIZA) = 32 %, Mean (RSREU) = 46 %) (Hockicko et al., 2019).

The video analysis and simulations (VAS method) of problem tasks using interactive program Tracker is one of the methods that considerably helps to form conceptual thinking and at the same time eliminating misconceptions, to develop manual skills and intellectual capabilities of students and increase the level of knowledge of students and the results in post-test, too (Hockicko et al. 2014, Hockicko et al. 2016).

If we want to achieve better results with current student quality, it seems to be necessary to use more effective, interactive methods and to focus more on an active and creative, more conceptual approach in order to enhance the students' expertise rapidly in the beginning of their studies. The video-based problems, problem-based learning, project-based learning, inquiry-based teaching methods, internet-supported learning, conceptual question application and other enhance higher order cognitive skills and students do better than those attending a traditional lecture-lab type instruction (Hockicko, 2010, Hockicko et al., 2014, 2015, 2016).

Conclusion

Our results confirmed that the difference in the knowledge level between the experimental and control group was statistically significant, at the significance level of $\alpha = 5\%$ (the experimental group consisted only from those students who actively participated in the lectures from Physics in comparison with the control group – consisted of the students who did not attended lectures).

Watching real physics concept videos and their subsequent video analysis had a positive impact on the growth of knowledge and improving of conception of Newtonian mechanics at the end of the semester in the experimental group. The methods of video-analysis using the program Tracker presented in this contribution make learning physics easier for the students, they can set individual pace for their work and they have fun when analysing videos. We assume that with the help of interactive way of teaching physics it would be possible to eliminate misconceptions of students, decrease of the dropout of the first-year students and also to improve students' level of knowledge in the introductory courses of general physics. A detailed analysis of FCI tests can help us to detect preconceptions and problems in the conception of physics basic principles and the work of this world.

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References

Bussei, P., Merlino, S. (2003). European workshop on Multimedia in Physics Teaching and Learning. *Europhysics News*, 34(3), pp. 116-117. ISSN 0531-7479.

Dirner, A. et al. (2011). Students discover the beauty of particle physics Masterclasses 2011. *Proceedings of the conference Creative teacher of physics IV, National festival of physics 2011,* 1st ed. Bratislava: Slovak Physical Society, pp. 50 - 63, ISBN 978-80-970625-3-8.

Heck, A., Uylings, P. (2010). In a Hurry to Work with High-Speed Video at School. *The Physics Teacher* 48, pp. 176 – 181. ISSN 0031-921X.

Hestenes, D., Wells, M., Swackhamer, G. (1992). Force Concept Inventory, *The Physics Teacher*, vol. 30, no. 3, pp. 141–158.
Hockicko, P. (2010). Nontraditional Approach to Studying Science and Technology. *Communications*, Vol. 12, No. 3, pp. 66 – 71. ISSN 1335-4205.
Hockicko, P. (2013). Fyzika v príkladoch a videopríkladoch / Video-analysis based tasks in physics. 1.ed. Žilina: Edis, [DVD]. ISBN 978-80-554-0811-8. on-line: http://hockicko.uniza.sk/Priklady/video_tasks.htm
Hockicko, P. (2011). Forming of Physical Knowledge in Engineering Education with the Aim to Make Physics More Attractive. *Proceedings of International Conference Physics Teaching in Engineering Education PTEE 2011*, Mannheim, Germany, 2011. ISBN 978-3-931569-18-1.
Hockicko, P., Krišťák, Ľ., Němec, M. (2015). Development of students' conceptual thinking by means of video analysis and interactive simulations at technical universities. *European Journal of Engineering Education*, 40(2), pp. 145–166. DOI: 10.1080/03043797.2014.941337, ISSN 0304-3797 (Print), 1469-5898 (Online).
Hockicko, P., Rochovská, I. (2013). Detection, analysis and the possibilities on eliminating misunderstandings and misconceptions in the physics education at technical universities. *Proceedings of the conference Creative teacher of physics VI, National festival of physics 2013.* 1st ed. Bratislava: Slovak Physical Society, pp. 126 - 132, ISBN 978-80-971450-0-2.
Hockicko, P., Tarjányiová, G., Kopylova, N., Dyagilev, A. (2019). Video-analysis as an effective method for improving physics teaching and learning understandment, *Proceedings of the 10th International Conference on Physics Teaching in Engineering Education PTEE 2019*, The Hague University of Applied Sciences, Delft, The Netherlands, May 23-24, 2019, ISBN 978-90-9031874-5.
Hockicko, P., Tiili, J. (2015). Comparison of the Entering Students' FCI Results – Tampere UAS and University of Žilina, *Proceedings of the 43rd SEFI Annual Conference 2015 Diversity in engineering education: an opportunity to face the new trends of engineering*, Co-organised by SEFI and Polytech Orléans, Brussels, Belgium, on USB key, ISBN 978-2-87352-012-0.
Hockicko, P., Trpišová, B., Ondruš, J. (2014) Correcting Students' Misconceptions about Automobile Braking Distances and Video Analysis Using Interactive Program Tracker. *Journal of Science Education and Technology*, 23(6), pp. 763-776, DOI: 10.1007/s10956-014-9510-z, ISSN 1573-1839.
Hockicko, P., Tarjányiová, G. (2016). Force concept inventory of first year students attending Faculty of Electrical Engineering. *Proceedings of 11th International Conference ELEKTRO 2016*: Slovakia, Štrbské Pleso – High Tatras, May 16-18, 2016, pp. 665-669. IEEE Catalog Number: CFP1648S-DVD, 2016. ISBN 978-1-4673-8697-5.
Kopylova, N. (2018). The Use of E-Learning at Foreign Language Practical Lessons in a Technical University, *Proceedings of the conference: 12th International Conference Elektro 2018*, Location: Mikulov, Czech Republic, May 21-23, 2018, IEEE, 345 E 47TH ST, NEW YORK, NY 10017 USA, ISBN 978-1-5386-4759-2.
Laws, P., Pfister, H. (1998). Using Digtal Video Analysis in Introductory Mechanics Projects. *The Physics Teacher*, 36 (5), 282 – 287.
Mazgut, R, Spanik, P., Koscelnik, J., Sindler, P. (2014). The Measurement of Balance by the Accelerometer and Gyroscope, *Proceedings of the ELEKTRO 10th International Conference*, pp. 192 – 196, MAY 19-20, 2014, IEEE, 345 E 47TH ST, NEW YORK, NY 10017 USA. ISBN:978-1-4799-3721-9.
Ondrus, J, Karon, G. (2017). Video System as a Psychological Aspect of Traffic Safety Increase, *Proceedings of 17th International Conference on Transport Systems Telematics (TST)*, Katowice, Poland, Smart Solutions In Today's Transport Book Series: Communications in Computer and Information Science, vol. 715, pp. 167-177.
Pinxten, M., Laet, T. De., Van Soon, C., Peeters, C., Kautz, C., Hockicko, P., Pacher, P., Nordstrom, K., Hawwash, K., Langie, G. (2017). Approaches to the Identification of STEM Key Competencies in European University systems, *Proceedings of the 45th SEFI Annual Conference 2017*, 18 – 21 September 2017, Portugal, pp. 389 -397, ISBN 978-989-98875-7-2.
Redish, E. F. (2003). *Teaching Physics*, John Wiley and Sons, New York.
Spanik, P., Dobrucky, B., Frivaldsky, M., Drgona, P., Kurytnik, I. Measurement of swtitching losses in power transistor structure, *ELEKTRONIKA IR ELEKTROTECHNIKA*, Issue: 2, pp. 75-78, 2008, ISSN: 1392-1215.
Tarjányi, N., Tarjányiová, G. (2016). Sounds from the Country of Wave. *Proceedings of the conference Creative teacher of physics VIII, National festival of physics 2015,* 1st ed. Bratislava: Slovak Physical Society, pp. 215 - 222, ISBN 978-80-971450-8-8.