# Education Research Highlights in Mathematics, Science and Technology 2016

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Mack SHELLEY
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**Education Research Highlights in Mathematics, Science and Technology 2016**

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# *Section 1: Science Education*

# DEVELOPMENT OF THE SECONDARY-BIOLOGY CONCEPT INVENTORY (S-BCI): A STUDY OF CONTENT AND CONSTRUCT VALIDATION

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**ABSTRACT:** This project aims to develop a measurement tool for assessing the conceptual understanding of secondary grade-level biology students (ages 11 to 18) that is reliable and valid. The study reported here describes the validity assessment of Secondary Biology Concept Inventory (S-BCI). A pool of assessment tasks was designed to target major biology constructs. The assessment items' answer stems were developed to include distractors representing students' alternative conceptions obtained from literature and student interviews. The validation stage of the S-BCI development involved an iterative revision and review process to help establish sufficient S-BCI content and construct validity. This stage included (i) student interviews and (ii) multi-expert panel critique. Based on the results of the aforementioned analyses, assessment items were proven to be valid where included on the S-BCI.

**Key words:** biology, secondary education, concept inventory, and alternative conceptions

## INTRODUCTION

Concept inventories (CIs) are research-based measurement instruments used for assessing student understanding of concepts (Hestenes et al., 1992). These standardized selected response tests can be useful tools in measuring what students have learned in secondary science. Several existing CIs target tertiary-level conceptual understanding of specific topics in biology such as natural selection, cell division, genetics, and osmosis and diffusion (Anderson et al., 2002; Elrod, 2008; Nehm and Reilly, 2007; Odom and Barrow, 1995; Parker et al., 2008; Williams et al., 2008; and Wilson et al., 2006). Additionally, the college-level Biology Concept Inventory (BCI) includes the major concepts covered in a first-year undergraduate biology course. However, the BCI's validation process included college-level students and not secondary-level students (Klymkowsky & Garvin-Doxas, 2008). Although there are several existing CIs related to biology concepts, there is no fully developed CI available that collectively measures the major concepts covered in secondary biology classrooms. Thus, this study aims to develop a measurement tool for assessing the conceptual understanding of secondary grade-level biology students (grades 7 to 12) that is reliable and valid. In this paper, we describe the Secondary-Biology Concept Inventory (S-BCI) and its development and validation.

## METHODS

Our goal in developing the S-BCI was to design a concept inventory grounded in student understanding that would be able to measure the thinking of a large, diverse sample of secondary-level biology students. The instrument needed to produce both reliable and valid data while distinguishing among students with different levels of

secondary-level biology knowledge. With these goals in mind, the S-BCI was developed based on alternative conceptions identified from both a literature review and student interviews (*N*=15). Pools of assessment items were created for consideration (*N*=61) and then modified based on feedback from Expert Panels, composed of biology content experts as well as master level biology high school teachers.

**S-BCI Constructs and Item Development**

The S-BCI was designed to assess secondary-level students' understanding of core concepts (Table 1). These core concepts were identified by surveying a panel of biology teachers and experts about which concepts represent the fundamental models in the field of biology and are taught at the secondary-level. The following five core concepts emerged from this survey: (i) evolution and diversity, (ii) population interactions, (iii) growth and reproduction, (iv) inheritance, and (v) energy and matter. Each core concept aims to address an essential question (Table 1).

**Table 1.** Essential questions associated with the core concepts

| Core concepts in S-BCI | Essential questions |
|---|---|
| CC1. Evolution and diversity | How and why do populations change over time? |
| CC2. Population interactions | How and why do populations in a system interact with other populations over time? |
| CC3. Growth and reproduction | How is information preserved during reproduction while still produce the variation observed in life? |
| CC4. Inheritance | **How are traits passed from parents to offspring?** |
| CC5. Energy and matter | How and why do energy and matter transfer within and across systems? |

An average of 12 single-tiered items were written or adapted from other assessments targeting the core concepts associated with each model (Table 2). A total of 61 selected response items were developed. Each item was comprised of question stem and four to seven possible responses. Many of the distractor responses represented alternative conceptions identified by practitioner observations and empirical research.

**Table 2.** Core concepts in S-BCI

| Core concepts in S-BCI | Total number of questions |
|---|---|
| CC1. Evolution and diversity | 13 |
| CC2. Population interactions | 12 |
| CC3. Growth and reproduction | 13 |
| CC4. Inheritance | 11 |
| CC5. Energy and matter | 13 |
| TOTAL | 61 |

**Validation**

The validation stage of the S-BCI development involved an iterative revision and review process to help establish sufficient S-BCI content and construct validity. This stage included (i) student interviews, (ii) student questionnaires, and (iii) multi-expert panel critique. Based on the responses from the multi-expert panel review, student questionnaires, and student interviews, the S-BCI items were revised.

The multi-expert panel critique stage entailed receiving feedback from two distinct panels: (i) Biology Expert Panel and (ii) High School Expert Panel. The Biology Expert Panel was comprised of five staff and faculty members representing three distinct universities. The High School Expert Panel included eight teachers representing eight public and private high schools. These eight teachers had on average 17 years of experience. These panels critically analyzed the S-BCI for factual/conceptual accuracy, diagrammatic accuracy, alternative conception alignment, and the age-appropriateness of item structure and content including readability metrics.

The student interview stage involved students who were enrolled in undergraduate courses at a public large university (*N*=7) and secondary students enrolled in a biology course at a public high school (*N*=8), respectively. These public learning institutions are both located in the Midwestern United States. Using a "think aloud" interview structure, students, both undergraduate and high school, were asked to explain their understanding of each item's question stem and answer stems.

Additionally, secondary students completed an open-ended questionnaire which asked students to explain their understanding of the items' question stems and common vocabulary terms used in the S-BCI (*N*=73). These

interview and questionnaire data were explored for alternative conceptions lacking an empirical presence in literature, in addition to analyzing if students chose correct answers for the correct reasons. Based on the responses from the multi-expert panel review and student interviews and questionnaires, the S-BCI items were revised.

## RESULTS

In validating the S-BCI, the first stage of developing content and construct validity included student interviews. From these student interviews, items that were designated as having 'validity concerns' were edited for student questionnaires. Generally, the validity concerns of the assessment items fell under 3 categories: (1) confusion about the wording and problems with complex terms, (2) a lack of understanding of figures associated with the question, and (3) unanticipated alternative conceptions. Each category is briefly defined and then an exemplar is provided to illustrate the S-BCI validation process.

The first category, confusion about the wording and problems with complex terms, is associated with vocabulary within the question stem that students did not understand. These words were first identified in the undergraduate student interviews by students either asking for clarification of the term or a lack of understanding of the terms' definition after further questioning.

The second category, a lack of understanding of figures associated with the question, was discovered during undergraduate interviews and further explored in the high school interviews. During the interviews, each figure was evaluated on two criteria: (i) whether the figure was appropriate for the question; and (ii) whether the figure was necessary to answer the question. Figures that were highly complex and/or not descriptive enough were revised following the undergraduate interviews. The revised figures were then shown during interviews to high school students and further revised when necessary.

The third category, unanticipated alternative conceptions arose from adjustments made to the question stem or response options as a result of alternative conceptions students had that were discovered through the interviews. Exemplar for each category and its progression from expert panel through interviews is described below. These exemplars represent examples of how items were modified during the S-BCI validation process.

### Exemplar I: Confusion about Wording

The first exemplar assessment item represents an example of a question that was identified as having validity concerns during the expert panel review and student interviews because of lexicon complexity. The original item (Figure 1) was developed for the Dominance Concept Inventory (Abraham, Perez & Price, 2014). This question was incorporated into the S-BCI because the item aligned with the S-BCI's Inheritance Core Concept (Tables 1 and 2). Furthermore, this task targets common alternative concepts held by some secondary-level students. For example, if a student selects distractor B, then the students may have the alternative conception that within a population, the selective advantage of a particular phenotype is determined by the phenotype's impact on survival and reproduction (Abraham, Perez & Price, 2014).

**Figure 1.** Original question (Abraham, Perez & Price, 2014)

A rose population has two alleles of a gene for thorn length. Long thorns help protect the roses from herbivory by deer. Allele H1 codes for long thorns, while allele H2 codes for short thorns. Given this information, please indicate which of the following a biologist would infer about the mode of inheritance for allele H2?

a) It is dominant.
b) It is recessive.
c) It is co-dominant.
d) It is impossible to determine.

The original question (Figure 1) was reviewed by both the Biology Expert Panel and High School Expert Panel. The expert panel review data suggested that description of the allele variants (i.e. allele H1 codes and allele H2 codes) may cause student confusion. The term 'herbivory' was also identified as a term that may lead to student comprehension issues. Therefore, this question was edited to reduce student confusion towards science specific lexicon (Figure 2).

**Figure 2**. Edited question after expert panel review

In a rose population, there are two variants for thorn length, short thorns and long thorns. Long thorns help protect the roses from being eaten by deer. Given this information, please indicate which of the following a biologist would infer about the mode of inheritance for short thorns?

a) It is dominant.
b) It is recessive.
c) It is co-dominant.
d) It is impossible to determine.

The assessment item in Figure 2 was further evaluated for validity during the undergraduate interview stage. During these interviews, the students indicated that the phrase 'mode of inheritance' could be reworded in order to reduce terminology confusion. As a result, the phase 'mode of inheritance' in the original question (Figures 1 and 2) was replaced with the phrase 'the way [thorns] are inherited' (Figure 3). Furthermore, the answer stems were expanded to include descriptions of student reasoning related to her/his conceptual understanding. That is, if a student selects choice A, then that student is likely to have the alternative conception that dominant traits provide an adaptive advantage.

**Figure 3.** Edited question after undergraduate interviews

In a rose population, there are two variants for thorn length, short thorns and long thorns. Long thorns help protect the roses from being eaten by deer. Given this information, please indicate which of the following a biologist would infer about the way short thorns are inherited?

a) It is a dominant inheritance pattern because short thorns have an adaptive advantage.
b) It is a recessive inheritance pattern because short thorns are more widespread in the population.
c) It is a co-dominant inheritance pattern because both long and short thorns are found in the population.
d) It is impossible to determine.

**Exemplar II: Figures Associated with the Question**

The second exemplar assessment item represents a question that was identified as having validity concerns related to figure representation during the expert panel review and student interviews. The original item (Figure 4) was developed by the research team for S-BCI because the item aligned with the S-BCI's Evolution and Diversity Core Concept (Tables 1 and 2). The assessment item targets common alternative concepts held by some secondary-level students. For example, if a student selects distractor D, then the students may have the alternative conception that natural selection is only related to the survival of the strongest organisms in a population.

**Figure 4.** Original question

A biologist has been growing a population of bacteria on a growth media containing an antibiotic for 2 days and then switching the bacteria to media without the antibiotic for 2 days. The biologist noticed that initially very few bacteria survived (i.e., were resistant to the antibiotic), but now almost 100% of the bacteria survive. He proposes that

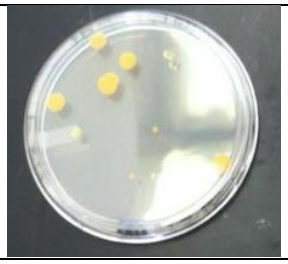
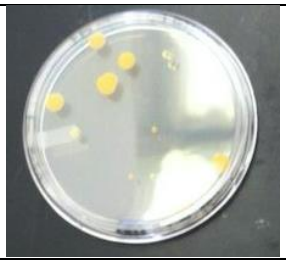
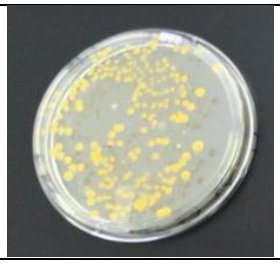
a) The environment (the growth media with the antibiotic) caused the bacteria to become resistant to the antibiotic. Each generation more bacteria changed and so now more survive.
b) The environment (the growth media with the antibiotic) caused the bacteria to become resistant to the antibiotic. These bacteria survived and increased their reproduction more than nonresistant bacteria and so now more survive.
c) Initially, some bacteria were resistant to the antibiotic and some weren't. The environment (the growth media with the antibiotic) allowed those that were resistant to survive and reproduce better than the nonresistant bacteria and so now more survive.
d) Initially, some bacteria were stronger than the other bacteria. The environment (the growth media with the antibiotic) allowed those that were stronger to survive and reproduce better than the weaker ones and so now more survive.

During the next phase of the validation process for this item, the expert panels' suggestion that the context of the question stem assumed knowledge of laboratory procedures and equipment/materials in addition to understanding natural selection in bacteria populations was incorporated into the modification of this question. Specifically, the panel proposed that including a pictorial representation would help students conceptualize the laboratory procedures and equipment/materials associated with this item (Figure 5). For the undergraduate interviews, the question was edited to include more information within the table including the images. During the undergraduate interviews, there was confusion surrounding the abundance of information that was initially given in paragraph form. Several of the undergraduate students found the information redundant. All of the information about the

biologists' procedures were summarized in the table, rather than in a paragraph within the question stem. The term "media/medium" was removed and replaced with "dish" because the word "media/medium" directed students towards thinking about digital media rather than growth media. After the undergraduate interviews the question was edited as shown in Figure 5.

**Figure 5.** Edited question after undergraduate interviews

A biologist is conducting an experiment using bacteria. See the figure below for her procedure:

| **Day 1** | **Day 2** | **Day 3** | **Day 4** |
|---|---|---|---|
|  |  |  |  |
| Bacteria (small dots) in a dish containing nutrients and an antibiotic. | Bacteria in a dish containing nutrients and an antibiotic. Some of this bacterium is moved to the new dish on day 3. | Moved bacteria in a dish containing no antibiotic. | Bacteria in a dish containing no antibiotic. |

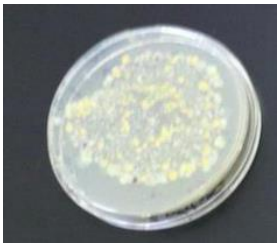
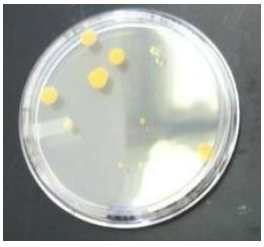
After a year of doing this rotation with this population of bacteria, the biologist noticed that, while initially very few bacteria survived, now almost 100% of the bacteria survive when placed in a dish with nutrients and an antibiotic. What might she conclude:

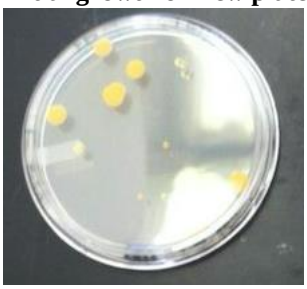
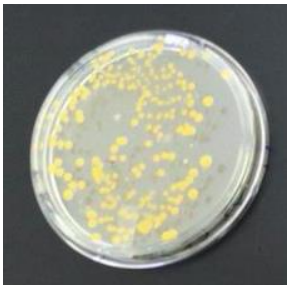
a) The environment (with the antibiotic) caused the bacteria to become resistant to the antibiotic. Each generation more bacteria changed and so now more survive.
b) The environment (with the antibiotic) caused the bacteria to become resistant to the antibiotic. These bacteria survived and increased their reproduction more than nonresistant bacteria and so now more survive.
c) Initially, some bacteria were resistant to the antibiotic and some weren't. The environment (with the antibiotic) allowed those that were resistant to survive and reproduce better than with the nonresistant bacteria and so now more survive.
d) Initially, some bacteria were stronger than the other bacteria. The environment (with the antibiotic) allowed those that were stronger to survive and reproduce better than the weaker ones and so now more survive.

During the high school interviews, it was found that high school students continued to find the images as confusing. Students associated the same growth plate across all four days without understanding the different types of combinations of nutrient and antibiotic in each plate. Therefore, after high school interviews the figure was redesigned so that the days of the dish containing both nutrients and antibiotic from those of the dish containing nutrient but no antibiotic were separated from each other. The edited image for the question can be found below in Figure 6. The question stem and choices for response remained the same.

**Figure 6.** Edited question after high school interviews

**EXPERIMENT 1:** Bacteria is grown in the initial growth plate. The biologist adds antibiotic to the plate and checks the plate after 1 week. The bacterial growth is shown in the second plate below.

| **Initial Growth** | **Growth after 1 week** |
|---|---|
|  |  |
| View of plate from initial growth | View of plate 1 week after adding antibiotic |

| **EXPERIMENT 2:** The biologist removes bacteria from the second plate (above) and puts it on a new plate (without antibiotics) the initial growth and growth after 1 week are shown below**.** | |
|---|---|
| **Initial growth on new plate** | **Growth after 1 week** |
|  |  |
| View of bacteria on new plate (without antibiotics) | View of bacteria after 1 week on new plate (without antibiotics) |

**Exemplar III: Unanticipated Alternative Conceptions**

The final exemplar assessment item represents an example of a question displaying unanticipated alternative conceptions held by students. This validity concern emerged only during student interviews, and thus was not identified during the expert panel critique. The original item (Figure 7) was adapted from the Diagnostic Question Clusters related to Tracing Matter in Dynamic Systems assessment (Wilson, Anderson, Heidemann, Merrill, Merritt, Richmond, Silbey, & Parker, 2006). This question was incorporated into the S-BCI because the item aligned with the S-BCI's Energy and Matter Core Concept (Tables 1 and 2).

**Figure 7.** Original question (Wilson et al., 2006)

A mature maple tree can have a mass of more than a ton (dry mass, after removing the water), yet it starts from a seed that weighs less than 2 grams. Which of the following processes contributes the most to this huge increase in biomass?

a. Absorption of mineral substances from the soil via the roots.
b. Absorption of organic substances from the soil via the roots.
c. Absorption of carbon dioxide into molecules by green leaves.
d. Absorption of water from the soil into molecules by green leaves.
e. Absorption of solar radiation from the sun by green leaves.

While no edits were made following undergraduate student interviews, high school student interviews indicated that the question stem needed to be revised. Removal of the phrase 'maple tree' from the original question stem occurred because it was discovered during the high school student interviews that a specific type of plant guided the student into thinking about more complex structures that contribute to the increase in weight. Using 'maple tree' rather than general 'plant seed' directed students towards thinking of possible mechanisms for increase in weight that are maple tree specific. After the high school interviews, the question was edited as shown in Figure 8.

**Figure 8.** Edited question after high school interviews

A scientist weighed a plant seed and found that it was less than 1 gram. She planted the seed. When the seed was a height of 10 meters she weighed, it using a really big crane. She found it weighed over a ton. What do you think contributes most to this huge increase in weight?

a. Absorption of mineral substances from the soil via the roots.
b. Absorption of organic substances from the soil via the roots.
c. Absorption of carbon dioxide into molecules by leaves.
d. Absorption of water from the soil into molecules by leaves.
e. Absorption of solar radiation from the sun by leaves.

## CONCLUSION

After the expert panels and student interviews, both an undergraduate and high school, the refined S-BCI questions totaled 52. Nine of the original 61 questions were considered invalid. The remaining 52 S-BCI questions will be moved forward in large scale quantitative testing. Within the interview stage both undergraduate and high school students understood the questions with a mix of students conceptually targeting, both alternative and accepted conceptions, indicating that the items on the S-BCI vary in difficulty and included a range of conceptions within

student understanding. Table 3 (below) shows the finalized break down of core concepts embedded within the S-BCI that will be pilot tested in a wide-scale quantitative study.

**Table 3.** Core concepts in s-bci post panel review and interviews

| Core concepts in S-BCI | Total number of questions |
|---|---|
| CC1. Evolution and diversity | 13 |
| CC2. Population interactions | 9 |
| CC3. Growth and reproduction | 11 |
| CC4. Inheritance | 6 |
| CC5. Energy and matter | 13 |
| TOTAL | 52 |

Based on the results from the expert panel, undergraduate interviews, and high school interviews, we identified the items with validity concerns and were able to edit them in an iterative cycle in order to ensure that, at the end of this stage, the S-BCI would be ready to be pilot tested in a wide-scale quantitative study. In the wide scale, quantitative study, we will work to determine if the S-BCI is reliable.

## FUTURE STEPS

The next step in the development of the S-BCI is the reliability testing. This will include a sample of students totaling over 1800 students in grades 8 through 12. The S-BCI items will be administered to students enrolled in science courses at seven public high schools in five states. The students are from rural, suburban and urban areas of the United States. Each student received a test with 34 questions. The number of items given to each student ensured that each item would be given to multiple students in order to obtain discrimination data while also allowing for questions that would be taken by all students.

Quantitative analysis on the S-BCI will analyze item difficulty levels, discrimination indices, point bi-serial coefficients, and Ferguson's delta. These are separated into individual item analysis and whole test analysis. Individual test analysis includes item difficulty levels, discrimination indices, and point bi-serial coefficients. Ferguson's delta is a whole test reliability analysis.

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# DEVELOPMENT OF CHILDREN'S UNDERSTANDING OF THE SURFACE ORIENTATION OF LIQUIDS

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**ABSTRACT:** In this chapter is analysed the development of children's understanding of the concept of horizontal position of the liquid surface. Numerous studies have found that most children and approximately 40% of the adult population behave as if they do not know that liquid remains horizontal, regardless of the orientation of its container. The sample consisted of students from six classes in elementary school "Ivo Lola Ribar" and "Dositej Obradovic" in Sombor (Serbia). The project "Water is precious" was implemented in three of tham and lasted from March to June 2015. The paper presents the experience and difficulties in adopting corect concept about surface orientation of liquids. Based on the study findings, conclusions were drawn and possible solutions were offered. The study has once again confirmed that the one-time doing of experiments, without continuity in observation and experimentation is insufficient to properly and permanently adopt certain scientific notions and concepts such as horizontal position of the liquid surface.

**Key words:** Scientific concepts and notions, basic properties of a liquid, science in primary school teaching

## INTRODUCTION

Teaching practice in Serbia is mostly focused on the implementation of the curriculum, innovative methods are rarely used, as well as, correlation between the subjects. Students are not required to predict and present different ideas and arguments, check them and provide evidence (Bošnjak, Branković, Gorjanac Ranitović, 2013; Cvjetićanin, Branković, Petrović, 2014).

Teaching methods based on inquiry-based activities, like project-based learning, have proven their effectiveness, in stimulating the interest of students, improving the level of their achievement and developing their functional knowledge and critical thinking (Expert Group of the European Commission, 2007).

The project-based learning means acquiring knowledge during the course of the project, which have to comply with the following elements:selection of topics from real life, challenging leading question, the students' voice and choice, developing skils of 21st century (cooperation, communication, critical thinking and the use of technology), students research, find innovation, conduct self-evaluation and public presentation of their results ((Larmer & Mergendoller, 2010; Chard, 2002 by: Curtis, 2002). In the proces of project-based learning project task has to be in the form of research, research topic combines different scientific areas and involves cooperative learning (David, 2008).

We conduct action research to investigate the practical possibilities of introducing project-based learning in teaching practice in Serbia, through the identification of specific features, problems and difficulties in its implementation and to find possible improvements. The research revealed one part of the study findings related to adoption correct concept about surface orientation of liquids by students of the third grade of elementary school. For proper understanding of the research problem the developmental abilities of children are important. Child's development is reflected in its specific ways of understanding the world around them, including the space. Before they go to school, children have acquired the implicit and the non-numeric knowledge of shape, position, distance, spatial orientation and directions.

### Epistemological Interpretation of Space

Genetic construction of space, besides the whole mental development, is in line with the whole biological evolution. Construction of space derives from position of our bodies and our senses, develops through the perceptive and sensory-motor evidences of space, and finally is shaped by deductive geometrical operations within

the intellectual part of our brain cortex (Piaget, 1994, p. 132). The basic spatial relationships are based on elementary topological relations such as proximity,distinction (separation) and continuity, which further depend on the initial sensory actions such as view centering and touch (Piaget, 1994, p. 163).

According to Poincare (Jules Henri Poincare) the one who could follow movements in the outside world, has to coordinate its own movements, and from this coordination could follow the structure of "group" (movement of the body itself, form a single "group"). Poincare boldly asserts that "for a completely motionless being, there would be neither space, nor geometry." Piaget concludes that the fundamental consequences of the previous statement are that "some of the displacements of the body initiates structuring of the external developments according to a correlative model, which is a mixture of convention and experience. Thanks to the same process, three dimensional concepts and Euclidean structure are attributed to the external space"(Piaget, 1994, p. 170-171).

A precondition for the proper construction of the space, is structuring the child's intuitive space per axes that is provided by vertical and horizontal objects. The vertical position of the body, that is established very early in the childhood (second half of the first year of life), does not allow the child to intuitively present himself verticals and horizontals, or that coordinate them with each other, until seven, eight years of age (Piaget, 1994, p. 144). Perceptual coordinates (horizontal and vertical) depend on the perceptual activity of comparing and bringing to relation observed objects and reference elements. Perceptual activities develop and enrich through a series of stages, in order to integrate with the intelligence about the age of eight, or nine.

For the understanding of space, and subsequently surface orientation of liquids, it is important to develop the concept of conservation. Conservation is the ability to view that quantitative properties of matter (quantity, mass, weight, length, area, volume) remain unchanged, although it changes its external characteristics (shape, place and order in space). This becomes apparent for child only on the basis of the conclusion which is not derived from the observation, but is the result of intellectual constructions performed by using mental operations. Thus, the conservation of quantity of matter and length occurs about 7-8 , the conservation of weight around 9-10, and volume conservation only about 11-12 years of age (Korać, 2012, p. 10).

Quantity conservation is achieved by learning that the parts unify into a whole, through reversible composition based on the relationships of the one part to the whole, without determining quantitative relations between the parts ( $A+A' = B \Rightarrow A < B \wedge A' < B$).Therefore elementary coordinate systems are firstly built, before any metrics, as correspondence of parts arranged in two or three dimensions, followed by compositions of "displacement", before their metric quantification, as change of the order or position. Developing capacity to construct the one part that can be repeated, and thus can serve as a unit, the process of constructing concept of measures is brought to the end, which logically and genetically runs almost in parallel to the process of number concept construction. However, for mathematization of space, except metric quantity, it is necessary to develop a formal thinking, and for it characteristic propositional logic (Piaget, 1994, pp. 196-205).

Picturesque spatial intuitions are formed in true geometric operations through three systems of spatial operations:

- Transformation of close figure (topological relations) - from ten to eight years of age;
- Coordination of the observation points from which the figures are transformed (projective relations) - about eight, nine years of age;
- Transformations that are consequence of displacement and that are related to the coordinate axes (Euclidean relations including similarities to) - about the eighth, ninth years of age (Piaget, 1994, pp. 191-192).

In addition to the mathematical (geometric) space which is the result of subjective coordination, there is a physical (empirical) space that applies to objects and their own properties. The physical space is no object property that can be extracted from its context, or, all the transformations that are logically possible (within the mathematical space) are not physically realizable. In the course of cognitive development, originally developed intuitive space, due to the separation of spatial operations, is replaced by formalized (matematical) and experiential (physical) space. Thereby, individual actions are a source of physical findings (including physical space), while the general coordination of actions are a source of logical-mathematical knowledge (including geometric space) (Piaget, 1994, pp. 237-241).

**The Development of Space Understanding**

Piaget defines four basic stages of cognitive development: sensorimotor (0-2 years og age), preoperational (2-7 years of age), the stage of concrete operations (7-11 years og age) and the stage of formal operations (11-15 yearsof age). Passing through various stages during the child's development, cognitive development is reflected in its specific ways of understanding the world around it, including the space.

During the sensorimotor stage a child develops coordination schemes between eye and hand and adopts the concept of object permanence. Preoperational stage is characterized by the development of symbolic thinking which is also reflected through development of speech. At the stage of concrete operations child is able to perform basic operations with concrete objects such as classification and seriation. Through the last stage, stage of formal operations child acquires the ability of abstract thinking, hypothetical reasoning and metacognition.

Before going to the school, the child has acquired the implicit and non-numerical knowledge about the shape, position, distance, spatial orientation and directions. Proper understanding of the space also depends on the egocentrism of the child, because it is centered on the individual aspects of the space and relations of elements in it, but not on an objective system of relations (spatial coordinates). Thus, the child from the age of seven and up to the age of nine, ten, will draw crossed paths parallel, because it focuses on each of them individually, rather than on their mutual relationship. (Korać, 2012, p. 13-14).

Mistakes that children make when draw horizontal and vertical lines are the result of concentration on the relations of those lines which are the nearest (liquid surface in a glass compared to glass) rather than on relations of distant lines (liquid surface in a glass compared to the surface of the table) (Bryant, 2009, pp. 13). A typical is the famous Piaget's problem of water level (WLT -Water Level Task) ie, the problem of horizontality of liquid surface in inclined containers.

Piaget and Inhelder devised the water level task (WLT) to study children's understanding of the spatial-coordinate system. Bottle half-filled with water were presented to child and after that, a similar empty bottle researchers tilted at various angles. Child had to indicate the direction of the water level if this bottle will be half-filled with water. Results showed that different errors were typical at the preoperational and concrete-operational developmental stages (Pascual-Leone & Morra, 1991).

Later research shown that many people (bouth, adult and children) do not know that water surfice remains horizontal, regardless of the orientation of its container. They have problem with water level representation, not because they are lacking the relevant knowledge, but rather because they are attempting to solve a different problem, a problem represented in an object - relative, as opposed to an environment-relative coordinate system (McAfee & Proffitt, 1991).
Around the age of eighth, ninth the child's intuitive space is structured by the coordinate axes that are provided by vertical and horizontal structures. Nine year old child still has problems with the logical implication, such as establishment of a connection between two ideas or two premises, as well as transitive inferences, which are the basic logical precondition that underlies measurement.

## METHODS

The research problem was investigation of the process of adopting the scientific concept of horizontal position of the liquid surface. The choice of research problem derives from the awareness and experience about the difficulties in the acquisition of complex concepts. Result was adoption of unrelated facts by students, not the concept itself, which would be a necessary precondition for the creation of functional knowledge. Project-based teaching has been recognized as a possible solution to overcome these problems by increment students' motivation and contribute to a fuller and deeper adoption of scientific concepts.

The aim of this research was to detect difficulties in adopting corect concept about surface orientation of liquids and to find possible ways of improvements.

The study sample consisted of 116 third grade students (59 students in the experimental group and 57 students in the control group) from six classes in elementary school "Ivo Lola Ribar" and "Dositej Obradovic" in Sombor (Serbia), and in three of tham are implemented the project "Water is precious", which lasted from March to June 2015.

## RESULTS AND FINDINGS

The studentsof the experimental group were asked to do the experiment with a bottle and colored liquid in it. They were supposed to rotate and tilt the bottle and at the same time observe the position of the liquid surface. After the experiment, they should have to conduct a conclusion on whether the position of the liquid surface changes when changing the position of the container, or remains in the same position. During the experiments we observed that many students had difficulties to distinguish change of the shape of liquid surface from change of the position of

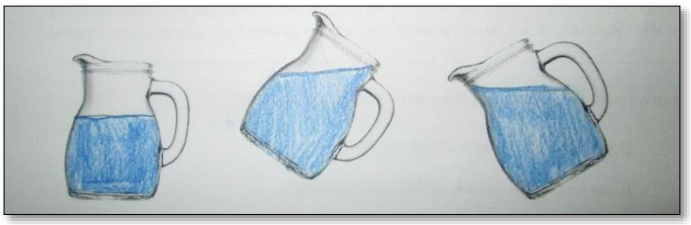
liquid surface (Figure 1). It was necessary to correct the experiment in a way that a ruler or a piece of paper was leaned in parallel to the surface of the liquid, and then, tilt the bottle to observe whether a piece of paper/ruler remained parallel to the surface. This approach was helpful for some students, but not for all.

**Figure1.** Observing position of the liquid surface when changing the position of the container

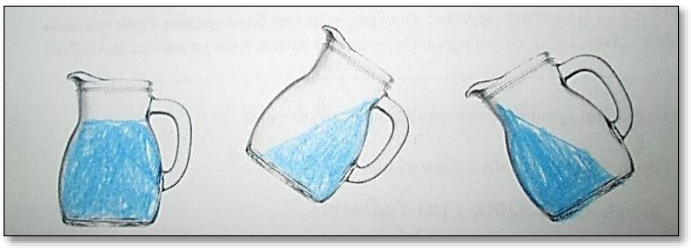
Check a thorough understanding of this seemingly simple and widely known scientific facts about the horizontal position of the water surface by question where they were supposed to draw the position of the liquid surface in an decanter or bottle represented in several different positions, confirme difficulties noticed during the experiments.

A few examples of solutions of the WLT at the initial test is shown on the Figure 2.

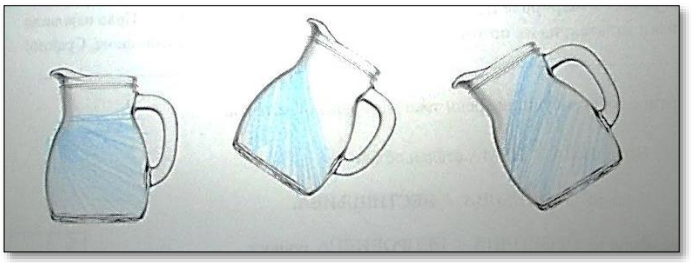
In tasks where they were supposed to draw the position of the liquid surface in an upright decanter or bottle, or, inverted bottle, there were no significant differences between the results achieved in experimental (E) and control (C) group, as well as, at the initial and final test in both group. Percentage of correct answer is between 90% and 100 %, which means that vast majority of students have no problem to draw the position of the liquid surface in these cases, regardless of whether they carried out experiments or not.



a) Appropriate inclination and the horizontality of the liquid surface



b) In the tilted decanters inclination of liquid surfice is on right side, but horizontality still missing.



c) In the tilted decanters inclination of liquid surfice is on wrong side and horizontality missing too.

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d) In the tilted decanters liquid takes up lengthwise half of the decanter.

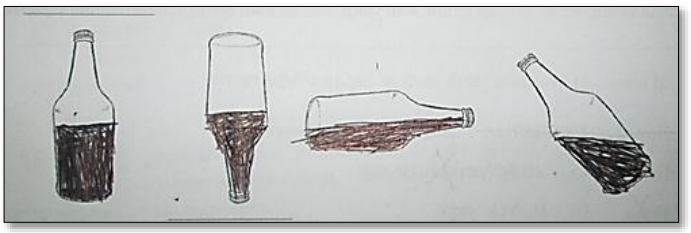
e) Liquid **is** not drawn in the tilted decanters.

**Figure2.** One example of correctly and four examples of incorrectly drawn fluid level in the tilted decanters at the initial test

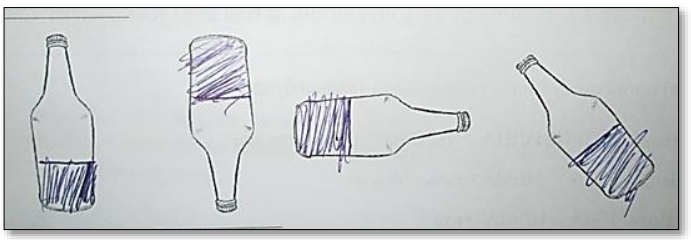
If we analised their drawings about position of the liquid surface in a tilted decanter/ bottle, both, experiemntal and control group showed worse results at the initial test. Percentage of correct answers in experimental gorup is: $E_R$ - 28,33% respectively $E_L$ – 31,67%, and in control group is $K_R$ – 44,1% and $K_L$ – 4 7% (index L and R indicate the part of the task where the decanter tilted to the right, respectively, to the left side).

In the final test, the percentage of correct answers was higher for 10 - 15% in the both groups regardless of the experimental experience of students of E group. But the result is generally very low, because the percentage of correct answers in group E is 44%, and in the K group 58% .

A few examples of solutions of the WLT at the final test is shown on the Figure 3.

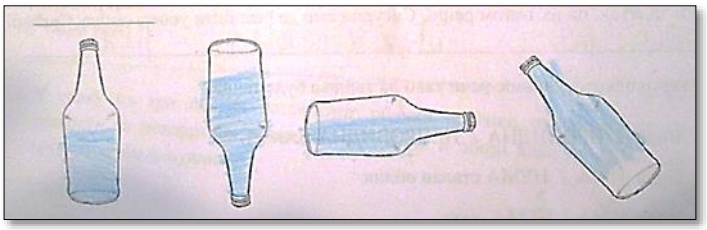


a) Appropriate inclination and the horizontality of the liquid surface

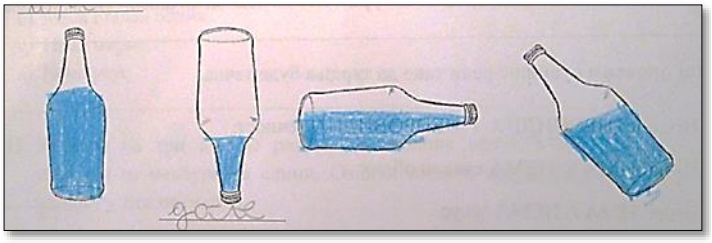


b) In all bottle positions the liquid has the same shape and position.

c) In the tilted bottles liquid takes up lengthwise half of the decanter.



d) At the bottom of the inclined bottle has no liquid.



e) In an inclined bottle surface of the liquid is not horizontal; in the inverted bottle presented volume of liquid is noticeably smaller than in other positions.

**Figure 3.** One example of correctly and four examples of incorrectly drawn fluid level in the tilted decanters at the final test

Results indicate that in tasks where they were supposed to draw the position of the liquid surface in an upright decanter or bottle, or, inverted bottle, there were no significant differences between the results achieved at the initial and final test, or between experimental and control group. We can conclude that students have no difficulty with surface orientation of liquids, in these two position. However, when they were supposed to draw the position of the liquid surface in a tilted decanter/ bottle students showed much worse results at the initial test. In the final test, the percentage of correct answers was slightly higher, but still very low, if we take into account experimental experience acquired in the meantime.

It seems that students have trouble understanding the concept that water level remains horizontal regardless of how the bottle is tilted through the verbal instruction. Or they maybe do not realize that is necessary to use reference outside the frame of the decanter/bottle. Same research suggest that practical experience promotes a functionally relative perspective, in which the orientation of the liquid's surface is evaluated relative to the container as opposed to being related directly to the surrounding environment (Hecht & Proffitt, 1995).

## CONCLUSION

Results show that almost half of the students even after conducting the experiment has not been able to properly draft the position of the liquid surface in the tilted bottle. This result can be explained in two ways. First, that students of this age (9-10 years) are not developmentally ready for the WLT yet because they have not coordinated the horizontal and vertical axes within a single system of reference, ie, that tilted container still confusing tham. The mistakes that children make when drawing horizontal and vertical lines are the result of concentrating on the relations of those lines that are closest (Bryant, 2009, p. 13). Some studies with American children found that children did not perform the WLT correctly before adolescence. (Geiringer & Hyde, 1976; Liben, 1978).

We also drew to the conclusion that is necessary a lot more practical experience in experimentation with focused observation position of surface of the liquid in the tilted containers that problem would be permanently overcome. Confirmation of such a claim we find in many studies about effectiveness of instruction on spatial skills. The results from different studies suggest that the WLT is teachable and that certain age groups are more responsive to teaching than others. Many of them describe a relationship between cognitive development and instruction effect on the WLT (Li, 2000). Some results indicate that children improve more on the WLT with the combination of instruction and practice than with practice alone (Li, Nuttall, & Zhao, 1999).

The results also have shown that single application of project was insufficient to support students' properly and permanently adopted certain scientific terms and concepts. That is why this education program should be applied permanently and as an integral part of the teaching process, not as a supplement to regular teaching activities. On the contrary, continuous application of project teaching would encourage independent research work of pupils, which means that they express their own assumptions, assessments, carry out examinations/experiments, notice and corrects their own mistakes and finally formulate and write down correct conclustions (Pavkov-Hrvojević at all, 2016).

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# BIOETHICS IN SCIENCE EDUCATION

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**ABSTRACT**: Recent developments in science will impact the practice of teachers who teach bioethics in schools. There is a growing awareness of bioethical issues amongst the public and in the media, and an increasing level of debate about them. It is important that teachers and those who teach biology are aware of the ethical and social implications of their work. This paper reviews and critiques the existing research on some bioethics, which deals with ethics in the context of science instruction. First, bioethics and bioethical issues are described. This is followed by an importance of bioethics education. Then the existing studies (on bioethics) are reviewed and evaluated. Because of the gaps with the existing research in the literature, recommendations are made describing the need for more and better designed research.

**Key words:** Bioethics, bioethical issues, biology, biotechnology, science education

## INTRODUCTION

In the last decades, technological developments have accelerated studies in biology and have enabled great improvements in genetics. It is important that biologists and those who teach science are aware of the bioethical and social implications of their work. The new developments in biotechnology such as isolating and combining genes, patenting life, secondary creation, eugenics and civilization, gene sociology, DNA computers etc. that can potentially shape this century also bring various ethical problems (Negrin, et al. 2007).

Scientific and technological developments lead to bioethical dilemmas that affect people's life. Like progress in molecular biology and genetic engineering and most recently, the human genome mapping topics may have already given rise to societal issues, which include bioethical aspects, as well as social and political ones (Larazowitz & Bloch, 2005). General scientific interest may play a role, as well as beliefs regarding science and technology (Osborne et al., 2003). Ajzen and Fishbein (2000) has stated that several background factors such as religious background, ethnicity, educational level, and gender also may influence people thoughts.

Today science curricula involve science and technology together with social, cultural, environmental, political, and ethical elements. It shows that importance of individual awareness of his/her own values and to explain them in a conscious way. Thus, today science education curricula highlight on the elements conducive to society-wide science literacy rather than conveying pure scientific knowledge to students. (Keskin-Samanci, Özer-Keskin & Arslan, 2013). Bioethics is necessary to advocate the relationship between the life sciences and values that are essential to society, and, at the same time, it is important that in the current context of the expanding applications of modern biotechnology and exigencies related both to human wellbeing and environment. In short, it is important that the public becomes more scientific literate in this respect. Science education occupies a central role in the development of scientific literacy (Driver, Leach, Millar & Scott, 1996). In recent years, the ethical topics in biosciences have become increasingly important in the field of science education as an important tool for improving students' scientific literacy (Kolarova & Denev, 2012).

Bioethical education among students and people is crucial that a necessity of contemporary moral education because of responsible for the future of humanity. In this article, we will describe the results of published literature on importance of bioethical education. The main aim of this study was to review and critique the existing research on bioethics, which deals with ethics in the context of science instruction.

### What is Bioethics?

Ethics has long been an integral component of medical and nursing degree programmes (Downie & Clarkeburn, 2005). It is clear that moral laws should embed with biological, medical, agronomical laws and this is how bioethical education contributes to educating students. Ethics education has been espoused by a number of professions in an effort to raise awareness of social and ethical issues and to enable the ethical decisionmaking skills required of people (Lysaght, Rosenberger III & Kerridge, 2006).

Although the term bioethics has multiple origins, it has generally been taken to mean medical ethics (Bryant & Baggott la Velle, 2003). Bioethics, which can be classified as a branch of the ethics plays a key role in the development and implementation of the respective means (Urker, Yildiz & Cobanoglu, 2012). Bioethics combines biological knowledge and knowledge about life with knowledge on the human, moral and ethical values.

According to Potter (1975), bioethics is a new discipline which combines biologic knowledge with knowledge of human value systems, which would build a link between the sciences and the humanities, help humanity to survive, and sustain and improve the civilized world. Ethics education also has a positive influence on students' ability to make decisions about ethical issues to raise a moral induvial ethics and as a specifically bioethics educationist important in schools. (Pinch & Graves, 2000).

**Why Bioethics Education is Important?**

At the present time, the rapid growth of technology has produced great improvements in biotechnology techniques. These improvements have created new controversial issues in science. Therefore, there is a need in science education to consider scientific research and its applications beside ethical concord. Bioethics education enables lots of benefits to humanity. Bioethics education makes it possible for individuals to accept the value conflicts caused by biological sciences and to develop decision-making skills based on ethical theories and principles (Reich, 1995).

Bioethical education enables to students to make the 'right' decision in a given situation, beside this bioethics education concerns itself with allowing them to have the scientific background necessary for ethical discussions and to improve their reasoning and decision-making skills (Sadler & Donnelly, 2006). Individuals can use these skills while interpreting scientific knowledge thus bioethics is important science education. Iancu (2014) stated that the purpose of the bioethical education is to educate students so as to apply moral laws in close correlation with the laws of biology in scientific research and scientific advances in biology, medicine, agriculture, and also in everyday aspects of their social, professional and family life and life in general on Earth.

Bioethical education is a bridge of some fundamental sciences, such as Education Sciences, Psychology, Biology (Greek bios=life; logos=science, speech), respectively, sciences that deal with the study of living creatures, Agronomy, Veterinary medicine and Human Medicine (Medical Sciences). The scheme is given below in Figure 1(Iancu, 2014).

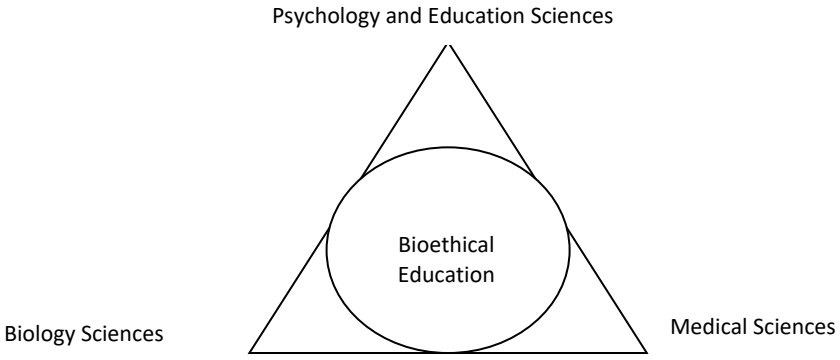


**Figure 1.** The scheme of the fundamental science of bioethical education

Fundamental aim of bioethics education to allow students to discover their own values regarding existing ethical problems, to question and evaluate them in light of universal ethical values, and to accomplish decision-making skills in problem-solving processes (Keskin-Samanci, Özer-Keskin & Arslan, 2013).

In literature, there are many studies which investigated importance of bioethics education in science. Another part of this paper is mentioned these studies.

## REVIEW OF THE RESEARCH ON BIOETHICS EDUCATION

We searched Web of Science using the search term bioethics education. This search resulted in the retrieval of over 750 studies. Later we marked education and educational research area, article document types and English language. This search resulted in a total of 48 research articles that met our criteria. We went through each of these studies, selecting those that relevant to our review. Specifically, our criteria for inclusion included any study that had implemented bioethics education in science. In the literature there were many studies that described bioethics

education (e.g. Bradbury-Jones & Alcock, 2010; Howard, McKneally & Levin, 2010; Pinch & Graves, 2000; Mills, 2015). These studies were in many fields such as medicine, biochemical, law, nurse education. However, the goal of this research was to determine studies in science education disciplines. Our review of the research includes nine research articles.

The first of them is the inventory development article. Keskin-Samanci, Özer-Keskin and Arslan (2013) developed the Bioethical Values Inventory that can be used to reveal secondary school students in Turkey ethical values in decisions that they make during ethical debates regarding the application of biological sciences. In this study, researchers described the development process of the inventory step by step. The Bioethical Values Inventory indicated the students' values in their decision-making processes, considering the objectives and nature of bioethics education. The inventory topics of scenarios are use of animals in experiments, prenatal genetic diagnosis and abortion, determining the gender or physical appearance of unborn babies, genetically modified organisms, genetic screening tests and therapeutic cloning. Researchers have thought that by using this inventory, the ethical values affecting individual decisions in ethical debates caused by biological sciences can be revealed with greater convenience.

Dawson (2007) studied that the development of understandings and attitudes about biotechnology processes as students' progress through high school. The students at this school consisted of new migrants from Europe and South East Asia and also the offering of language scholarships in Italian, German, and Indonesian to students outside the local area. It was conducted the cross-sectional case study. Data were collected with interviews and written surveys. It was found that students' ability to provide a generally accepted definition and examples of biotechnology, cloning and genetically modified foods was relatively poor amongst 12–13 year old students but improved in older students. Most students approved of the use of biotechnology processes involving microorganisms, plants and humans and disapproved of the use of animals. In addition, 12–13 year old students' attitudes were less favorable than older students regardless of the context.

A study reported by Sadler et al. (2006) investigated that teacher perspective on the use of socio−scientific issues (SSI) and on dealing with ethics in the context of science instruction. Middle and high school science teachers from three US states participated in semi-structured interviews. They found out two research questions: How do science teachers conceptualize the place of ethics in science and science education and how do science teachers handle topics with ethical implications and expression of their own values in their classrooms? As a result of the study five teachers' profiles emerged. Participants also expressed a wide range of perspectives regarding the expression of their own values in the classroom.

In 2005, Larazowitz and Bloch investigated awareness of high school biology teachers are of societal issues (values, moral, ethical and legal issues). The sample consisted of biology teachers. Data collected with questionnaires and personal interviews. Teachers' answers were analyzed in relation to years of teaching experience, gender and religion faith. The results show that amongst the teachers there is a medium to low level of awareness of societal issues. No differences is seen that teachers' opinions to societal issues were found in relation to gender or religious faith. The majority of the teachers do not include societal issues in their teaching. Teachers with more years of teaching experience tend to teach with a more Science, Technology, and Society (STS) approach than novice teachers.

Sadler and Zeidler's (2004) study examined the extent to which college students construe genetic engineering issues. Sample consisted of college students in United States. Data were collected with interviews. The study specifically addressed gene therapy and cloning. It was found that students' responses were influenced by affective features such as emotion and intuition. In addition to moral considerations, a series of other factors emerged as important dimensions of socio-scientific decision-making. These factors consisted personal experiences, family biases, background knowledge, and the impact of popular culture.

A bioethics module has been established by Bryant and Baggott la Velle (2003) at the University of Exeter in UK. The sample consisted of science and biology education students. The course was divided into four general topic areas (sociological, philosophical and ethical background; interactions of humans with the 'natural' world; biomedical topics; aspects of biotechnology). In this study, the syllabus was designed to give students the tools to at least begin to develop their thinking about and understanding of bioethical issues. In addition the course moved on to more specific topics, starting with environmental ethics as an issue with global implications, and then going on to deal with areas of medical, biomedical and biological science and biotechnology. Students carried out more detailed case studies in small groups, mentored by postgraduate students, and present posters on their case studies.

In a study conducted by Dawson and Taylor (2000), science students in two schools in Australia were taught biotechnology courses that introduced them to bioethics. At the end of the course, students completed a survey in which they made a decision about three bioethical dilemmas. They were asked to give reasons to support their decision. The students' answers and reasons were compared with those of three experts. Researchers found that the majority of students tended to resolve and justify their decisions in a way that was naive, idealistic, and rights based. Compared to the experts, the students seemed to give inappropriate emphasis to the bioethical principle of autonomy. Beside this, the explanations of students supplied to support their decisions suggested that they did not consider long term consequences.

Tsuzuki et al. (1998) investigated attitudes to animal experiments in Australia, Japan and New Zealand. The sample consisted of biology and a social studies teacher at randomly selected schools. Data collected with mail response questionnaires. Researchers surveyed the opinions of teachers in Australia, New Zealand, and Japan about bioethical issues in an International Bioethics Education Survey (Macer et al. 1994). Results indicated that almost all of the teachers thought bioethics were needed in education; found more teachers expressed concerns about animal rights or experiments in New Zealand, than Australia, and least in Japan. Among the biology teachers, 90 percent in New Zealand use animals in class, 71 percent in Australia and 69 percent in Japan. More than half of the samples said that they had ethical concerns about animal experiments, which were examined in responses.

Last study, was examined, reported by Asada et al (1996), compared knowledge and teaching of 15 selected topics related to bioethics and biotechnology, with particular focus on the teaching of social, ethical and environmental issues of in vitro fertilization, prenatal diagnosis, biotechnology, nuclear power, pesticides and genetic engineering. The sample consisted of biology and social studies teachers at high school in New Zealand, Australia and Japan. Data collected with International Bioethics Education Survey (Macer et al. 1994) via mail response like a Tsuzuki et al. (1998). It was found that bioethical issues were, generally, covered more in biology classes than in social science classes; and that there were differences in coverage among the three countries, with most coverage in Australia and least in Japan. Open questions looked at images of bioethics, and the reasons why about 90 percent of teachers thought bioethics was needed in education.

## CRITIQUE OF THE RESEARCH ON BIOETHICS EDUCATION

This paper began importance of bioethics education in science disciplines. Then, it was informed about the studies examined the literature.

According to findings of articles reported here do indicate that it can be difficult to appropriately assess students' socio–scientific discourse. Bioethics arguments can be useful for improvement of students' cognitive ability, and topics such as genetic engineering provide useful ways to stimulate this (Lucassen, 1995). Larazowitz and Bloch (2005) highlighted the need for the implementation of discussions on societal issues related to science, technology, and environment.

When examining the literature review with respect to bioethical issues, it was seen that these studies deal with use of animals in experiments, prenatal genetic diagnosis and abortion, determining the gender or physical appearance of unborn babies, genetically modified organisms, genetic screening tests and therapeutic cloning, gene therapy and cloning, sociological, philosophical and ethical background; interactions of humans with the 'natural' world; biomedical topics; aspects of biotechnology, ethical concerns about animal experiments, environmental issues. It can be said that the scope of this studies is wide.

Studies were performed in many counties (e.g., Turkey, US States, UK, Australia, Japan, New Zealand). It was generally found that individuals' responses were influenced by affective features such as emotion, attitude and intuition (e.g. Dawson & Taylor, 2000, Sadler & Zeidler, 2004). Although individuals' opinions also differ according to their country, generally the explanations of them supplied to support their decisions suggested that they did not consider long term consequences. Thus, it can be said that teachers need more teaching materials to discuss the bioethics values and ideas on further ways to teach biology and use animals in school (Tsuzuki et al., 1998). In this way they can put into practice a more effective ethic teaching.

The sample of studies was examined during the review. Keskin-Samanci, Özer-Keskin and Arslan (2013) study with secondary school students. Dawson's (2007) sample is 12-13 years old and older children. Bryant and Baggott la Velle (2003) emphasize the importance of awareness among biology science and biology education students of the ethical and social implications of their work. Dawson and Taylor (2000) worked with also science students. In Sadler and Zeidler's (2004) study college students were used as a sample. Sadler (2006), Larazowitz and Bloch (2005), Asada et al (1996) and Tsuzuki et al. (1998) worked with teachers. When the literature examined, It has

not been found to study at primary level. Therefore, it can be said that, studying with students at this level should be increased.

In these studies data collection method generally was interviews (e.g. Dawson, 2007; Sadler et al, 2006; Sadler & Zeidler, 2004) and some of the studies used the surveys (e.g. Dawson & Taylor, 2000; Tsuzuki et al., 1998). The bioethics education is also important as well as determining individual's views on bioethics. Bioethics education also can be done through the adequate scenarios while the students understand the relevant scientific facts and notice the ethical dilemmas in the scenarios (Keskin-Samanci, Özer-Keskin & Arslan, 2013).
This literature review highlighted the importance of scenarios of ethical dilemmas in bioethics education both for teaching and for reveal students' attitudes, values, and opinions (e.g. Dawson & Taylor, 2000; Keskin-Samanci, Özer-Keskin & Arslan, 2013).

## RECOMMENDATIONS

The main limitation of the study was that the number of articles which were examined was very small. For this reason, this study can only be regarded as restricted. For the future research, it can be reviewed that another indexes such as SCOPUS, ERIC and thesis. Although limitations have to be taken into account, the findings of this study highlight issues that may have to be considered by curriculum planners and science teachers who wish to incorporate scientific literacy into science curricula.

The results of this study provide some perspective in terms of bioethical issues. In the light of this study, the following recommendations can be given.

- Students should be given more opportunities to discuss bioethical issues. That is, bioethics should be a subject for study in science education.
- It can be recommended that teachers can do the 'bioethics education' through the scenarios.
- Science curricula at all levels of education should incorporate ethical issues of science.
- Discussion of ethical issues in science education should also be helpful to students understanding scientist because some of the students can be the future scientists.

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# EXPERIENCING INQUIRY WITH KINDERGARTEN: SCIENCE FOR KIDS

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**ABSTRACT**: Inquiry is not just about motivating children by providing them with hands-on activities but also help children to acquire with the required skills for observing, questioning, predicting, communicating, verifying the predictions, reflecting ideas with evidences, and making logical explanations. Even though many research is available for supporting these skills there has been some doubted on how to fit in inquiry skills with the age group 4-6. Therefore, this study aims developing inquiry framework through authentic activities with kindergarten children ages 4-6 (n=45). The frame of the activities is starting with a real problem such as "Have all the stones sink?", and then children discuss the issues by predicting. On the next level teacher encourage them to build observation, experiment and data-handling. Finally, they report and reflect what they discover through their evidence by working collaboratively with others and communicating their own ideas and considering others' ideas. During the program, sequential inquiry activities on different subjects were settled and performed at least 3 hours for 14 weeks. The techniques, which aims to record results obtained by illiterate preschoolers, of cutting gluing worksheets, drama, sheets of stickers, process of creating art products, picture completion, counting and scale measuring, matching, patterns, puzzles were used as worksheets and tools for data handling. During the process children's representing of their results in various techniques and their reasoning patterns was progressively supported. Over the time the activities help them to deepen understanding of being curious about daily issues in a questionable manner, inspiring an interest about science, verifying explanations or predictions with results, and verbalizing ideas about their experiences.

**Key words:** Inquiry learning, kindergarten, data-handling, observation, science activities

## INTRODUCTION

In terms of the nutrition experts' kids do not eat food, they only eat snacks. Thus, in early ages the conflict between the parents and the children start with the eating habits. When it comes to the school ages, kids do not learn as the adults say, they only be curios and discover, since if there are no curios and discover it means there is no enthusiasm. On the other hand, discovery and enthusiasm could not happen by sitting around a desk like the teachers want in school years. Subsequently, there will be not enough room for fun. Against all odds if the teachers force to put the information into the student's head, the conflict, withdrawal and loss of confidence activate in children. So, we educators might be better to inquiry and interpret our training again.

Inquiry oriented science education capitalizes on natural curiosity of children. Inquiry focuses on doing rather than acquiring. On the other hand, it is not just about motivating children by engaging them in hands-on activities (Finley & Pocoví, 2000; Minstrell & van Zee, 2000; Wheeler, 2000). Inquiry encourages children to construct knowledge in ways that are meaningful to them (e.g., Bruner, J. S., 1965; Edwards, C., Gandini, L., and Forman, G., 1998; Byrne, J., Rietdijk, W., and Cheek, S., 2016; Metz, K., 1995; Martin, R., Sexton, C., Franklin T., & Gerlovich, J. (2005).; Tyler, R. and Peterson, S., 2004).

The key element of teaching science as inquiry is to allow time for children to engage in dialogue with the material world by observing, questioning, predicting, debating, reflecting on data evidence, and make logical sense of their observations in a structured manner (Alberts, 2000; Artigue, et al., 2010; Crawford, 2009; National Research Council, NRC, 1996; Wheeler, 2000). Thus, the children will be engaged physically, mentally and socially not only scientific knowledge but also what it means to do science.

## METHODS

### Description of the Study

This study aims developing inquiry framework through authentic activities with pre-school students ages 4-6 (n=45). The frame of the activities is starting with a real problem such as "Have all the stones sink?", and then children discuss the issues by predicting. On the next level teacher encourage them to build observation, experiment and data-handling. Finally, they report and reflect what they discover through their evidence by working collaboratively with others and communicating their own ideas and considering others' ideas. During the program, sequential inquiry activities on different subjects were settled and performed at least 3 hours for each week which takes 14 weeks during the autumn and spring semesters. Sport, art and technology such as children games, stories, poems, songs, drama, gymnastic, painting, matchup, puzzles, classification and so on were used as a tool for data-handling since they illiterate.

The researchers used observation notes and the children' worksheets as tools in understanding the degree of effectiveness of the activities and the students' reflection to the inquiry based learning. Researcher notes are notes that reflect the researcher's own observations and sometimes the researcher's reactions (Yıldırım & Şimşek, 2006). Right after the class the three researchers come together around the round table and discuss their notes in terms of the questions *"What we have learned from this week? What should have us add more? How was the children's reaction to the activity? Were the children able to make connections to their everyday life?*" and etc." Three researchers one of them is instructor took observation notes. Two of the observers who are PhD students on science education collected data as indirect observation throughout the implementation.

### *The Role of the Teacher during the Study*

The role of the inquiry teacher in the classroom is not putting the knowledge into the student's head. The teachers by themselves have to open learning with their students. The inquiry teachers just accompany their students during the learning process by bridging with them an empathy without prejudge. The teachers themselves improve with their students.

How you are positioned in the classroom is very vital. If the position of the teacher is standing in front of the classroom, it should be very frightening for the small kids. Instead locating with the same level of the students for instance, if the students are sitting the teacher is better to sit next to them or if they are standing the teacher is better to locate near them doing the activities cooperatively and collaboratively would be better for children and also the teacher. The classroom atmosphere ought to be comfortable and friendly for kids (see Figure 1).

**Figure 1.** The inquiry classroom atmosphere

During the study, each week the teacher came to the classroom with a question. In some cases, she shares a problem from her laboratory and asks for help or she expresses one of her new activity and asks for to evaluate it. Bridging an intellectual and emotional intimacy with the children is very important. Theatrical expression, approaching with games and giving them roles are always help to catch their attention.

Expecting always the best from the children decreases their self-confidence. The inquiry teacher encourages their students to reflect by giving value to their ideas. There is no true or false idea in inquiry classroom. All thoughts are valuable. This is very important for introvert children since for a while they also finding courage to share their ideas. In close future, the students' ideas evolved better and a rich argument area is formed in learning context.

***The Inquiry Activities***

Inquiry based activities carried out in three stages accompanied by worksheets. The first stages of the worksheets help children to reflect their predictions with different techniques. The second stages ask children to state or keep their recordings to observations or experimental results. And the final stages aim verification which included comparison predictions and evidences (i.e. the results of the experiments) (see Figure 2).

**Figure 2.** Sample of activity worksheets

***Float or Sink***

Float and Sink activity caries out investigating floating and sink conditions of different kind of stones based on "Do all stones sink?" question. The students classify stone sapmles by observing and record their data with cut-and-paste technique used as data collection tool (see Figure 3).

**Figure 3.** Float and sink

***Magnets***

This activity consists of four game oriented activities; invention of the magnets, flying magnets, magnet detectors and magnets on the gift packs. In the first part of the activity, each child is given a bar magnet and a horseshoe magnet to let them do experiments on the interactions between magnets and interaction of magnets with other objects (see Figure 4).

**Figure 4.** Children experience the magnets

In the second part of the activity, children apply pressure to the circle magnets hovering on each other in a cylinder. In that way, they can understand magnetic attraction and repulsion features better (see Figure 5).

**Figure 5.** Magnetic attraction and repulsion

In the third part of the activity, children are asked to stick their stickers on objects in accordance with the objects' interactions with the magnets. In that way, all the objects in the classroom are classified as "affected by the magnets" and "not affected by the magnets" (see Figure 6).

**Figure 6**. Magnet stickers

In the last part of the activity, gift packs are prepared, 1 pack involves a magnet, 2 packs involve iron and 2 packs involve glass/wooden objects. Children were asked to find the gift magnet without opening the packs (see Figure 7). What is important in this activity is to find which one is iron and which one is magnet when two gift packs attract each other. Finally, children design magnets as an art activity.

**Figure 7.** Find the gift magnet

***Existence of Air***

In this activity, children collect evidence on the existence of air, the matter that surrounds us. A child blows a nylon bag by blowing into it 5 times. Another child swings a nylon bag in the air and knits it quickly. Inflated bags are compared. Gathered data are recorded as picture completion activity (see Figure 8).

**Figure 8.** Existence of air

In another activity, children measure the distance made by their air rocked they prepared with balloons and record those on their worksheets (see Figure 9).

**Figure 9.** Air rockets and worksheets

After that, a drum-like big plastic bucket is prepared by cutting off the bottom and covering it with a flexible material. Candles are snuffed or paper cups are knocked off by hitting the flexible side of the drum right opposite to them. Children get as many stickers as the number of knocked off cups (see Figure 10).

**Figure 10.** A drum-like big plastic bucket

Children prove the existence of air by touching, feeling and measuring. Finally, children are given a water-filled bowl, upper part of a plastic bottle, bottle cap and two jelly tots on top of little candle containers. Children are asked to find how to dive the jelly tots in the bowl without getting wet. In the preparation process, a cup (with cotton in its bottom) is submerged upside down in the water filled bowl. The data is gathered using labyrinth puzzle technique (see Figure 11).

**Figure 11.** Labyrinth puzzle technique and existence of air

***What Color is My Apple?***

Teachers developed a new discourse "Be creative!" in pre-school level to promote their students' creativity. However, these verbal expressions are not enough to enhance creativity. Individuals must think out of the ordinary to be creative. This can be achieved by experiencing different situations, determining the variables and manipulating these variables. For example, in order to say "be creative, paint different colored apples" to a student who is drawing apples; teacher must let the students experience at the first hand that apples can be in different colors depending on the light and apple's pigments. This thought is the groundwork for this activity. Red, green and yellow apples, bought from the market, are observed under red, blue and green light (see Figure 12). Painting is the data collection tool. Pre-and post experiment observations are recorded by painting colorless pictures of apples.

**Figure 12.** What color is my apple

***Plants Like Water***

In this activity, the students observe colors which are result of distribution and mixture of different colors and how a plant carries water to its leaves. The children cut papers in daisy shapes which were drawn in advance. Then they draw some dots on the leaves of paper flowers with marking pen and fold the leaves. After this, they put the paper flowers on a cup filled with water and start observing it. They use main motor skills such as cutting, folding, painting and drawing as data collection method with this activity (see Figure 13).

**Figure 13.** Plants like water

***States of Matter***

In this activity, the children change of the matter from solid state to liquid and gaseous state. They repeat the transformation process from solid state to gaseous state and gaseous state to solid state of matter. They use pattern technique as data collection method. Transforming water vapor into liquid is an interesting observation for the children (see Figure 14). Then, they discuss about states (solid or liquid) of an oobleck substance made of water and starch.

**Figure 14.** States of water

***Beak Activity***

The purpose of this activity is investigating the adaptation of living creatures. The investigation is carried out with a systematic process. The worksheets are prepared based on this order. Children are expected to make predictions according to research question. They ought to design an experiment with variables related to predictions and conduct the experiment based on the worksheets. Then they are expected to compare results of the experiment and their predictions in the beginning. Before the activity, students watch the tale of the fox and the stork or the story is told. Then the students are given a tablespoon and a pair of sticks or latches randomly. Food (coins, toothpicks or broken spaghetti sticks and marbles) is spread on the floor. Then children try to collect their food with beak models into plastic cups. They keep record of their data by painting boxes of bar graphs (see Figure 15).

**Figure 15.** Beak activity

***Observation of Pill Bugs (Armadillidiidae)***

In this observation-based activity which includes supporting thinking with variables, the children study on a crustacean living creature (*Armadillidiidae*) called as pill bug or ball bug in colloquial speech. Students investigate common environmental factors about these creatures by collecting data, picturing, designing an object and preparing observation report (Oguz, 2007). First, children observe these creatures with magnifying glasses and draw their observations (see Figure 16). During this process, teacher helps them to detail the observation with some questions such as “Do they have antenna? How many feet do they have? Do they have knots?”. The similar and different features of these creatures are put forth during the observation.

**Figure 16.** Observing pill bugs

Then the experiments are designed and conducted about habitable environments of these creatures (see Figure 17). They record data with comparing and drawing techniques in predicting, observing and evaluating processes during activity.

**Figure 17**. Pill bugs habitat

## RESULTS AND FINDINGS

In inquiry-based science practices of early childhood education, one of the difficulties of teaching through the evidences is to develop worksheets which are used by children who are illiterate (Burts, Hart, Charlesworth, & Kirk, 1990; Grossman, 1996; Marr, Cermak, Cohn, & Henderson, 2003; Wien, 2002). The techniques developed during the activities of the research allow children to record their evidences such as cutting gluing worksheets, drama, sheets of stickers, process of creating art products, picture completion, counting and scale measuring, matching, patterns, puzzles ext. has eliminated this problem.

During the inquiry, the questioning of the students is also directed from closed questions which have one correct answer to reasoning questions which are answered with arguments or reasons. For example, the questions of "*Is this bird eat grass?"*, "*Is there any offspring of this bird?"* give way to the reasoning questions of *"Why the beaks of birds are different from each other?"*

If inquiry is converted into 1-2 hours of demonstration activity, that kind of practices as an inquiry has no validity and reliability. Typically, amazing experiments in which higher visuality is presented in the form of demonstrations and children's attention is aimed to be taken. The pictures of the children staring in amazement are taken and shared in social media. This must be one of the most common situations that we currently encountered. However, a certain time of period should be spent for the children to feel comfortable in inquiry practices. It is claimed to be that the biggest challenge working with small children is their inability to abstract thinking. Therefore, science topics are considered to be inappropriate to the thinking of the children. The children to explain an idea by associating with something that is not there or with a phenomenon shows evidence of abstract thinking. For example, in the activity related to the existence of air, one child claims that we cannot see but we can hear the sounds during the phone conversations. During the beak activity, another child argues that the teeth of creatures are different and elephants, crocodiles, and other animals can be given as the examples for that. And one another child also claims that we cannot see the power of magnets but we can feel it. As a result, establishing the relationships between topics is the valid arguments for children's inquiry. A one higher level of that is for child to creating a new product with these relations.

It is observed that inquiry has an effective role in the language skills of children. In the activities, it is determined for the children using the words of *thing* instead of *objects* or *items*, *feed* instead of *what it eats*, *cloud* instead of *water vapor*, *push-sticking* instead of *push-pull*; *pattern* instead of *cycle.* The children learned how to use those words correctly within the process of inquiry. In course of time, children understood that their knowledge is dynamic and changeable. For example, after the floating and sinking activity, one child has commented as *"I have believed that formerly all the stones sink but after that I know that some are floating"*.

Children like the usage of different kinds of presentation techniques. In particular, screen and visuals are very important to them. Therefore, a cartoon telling the tale of the fox and the stork was used for the beak activity. Similarly, it was benefited from documentaries in some activities. For example, in the activity named all plants like water, children were very impressed by observing a flower how to be out in a slow motion.

The questions are asked children to encourage inquiry, for example: *"What would you like to explain/say me with this?".* However, some children may prefer remaining nonspeaking. If their friend launches forth upon something, the child who is nonspeaking encouraging by his/her friend can start to communicate about the topic. Meanwhile, when the teacher asked the question of *"How do you know that?"*, they started to query about what they never query before and to think about where their knowledge came from.

Children's ideas always need to be listening. When we asked randomly a boy *"what do you think about when a pillbug closing?*" while we have focused on inquiry with the idea that we should guide the activity appropriately, the boy suddenly threw himself on the carpet and twisted like a pillbug, and closed himself. The message implicitly sending us is that they closed like me when they are scared away. This is the strong argument to show inarguably paying attention to their ideas.

Inquiry allows children to think, to ask questions and to put forward their thoughts. Children can express themselves in different ways. The evaluation practices do not need to be in the form of standing up and saying or writing that we practice mostly in current school climate.

## CONCLUSION AND RECOMMENDATIONS

Consequently, it is very important to present a current issue as questionable way into children. If the teacher would like to create an effective discussion atmosphere with broad participation, putting children's daily life in the center of activities might be a solution. But here teacher has a responsibility for ensuring the balance, because there are no reservations and limits of children's behaviors. They can ask whatever they want.

Children have curiosity from the birth. There is no need to think abstract for making sense of life. It is important to emphasize the experiential ones. Increasing the child's imagination means improving the creativity. We need to expand our lives with our experiences. Educational activities should be activated. Therefore, it is important for educational activities to be taken into account. Highlighting this point for child as communication and stimulating this together help to bring curiosity into the open.

Consequently, our main purpose is to bring children together with science and to inspire an interest in science as opposed to the idea of providing the scientific concepts. We were able to continue the interest with these kinds of activities.

The observation range should be longer for students, because they need a time to distinguish one thing from the other within their wide inner world. During the activities, the use of the combination of both the motor skills and the operation of mental functions increase the children's recall and retention. If children are more aware of what is happening their around, they can be more intensely in the moment and they can jog the more their own memory.

Prediction practices are important for children to allow their self-evaluation, to associate their predictions with their experiment results, and to generate their own knowledge. We need to ask questions not because of asking question and getting answers but because of arousing curiosity. All these evidences give us hope to be made inquiry based practices with kindergarten children.

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# MICROSCOPE USAGE INFORMATION: SAMPLE OF SCIENCE TEACHER CANDIDATES

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**ABSTRACT**: A qualified laboratory lesson is of great importance in science education. In a qualified laboratory lesson, there are so many essential elements such as material, tool and place. One of the most important elements of a qualified laboratory lesson is the equipment used, and usage information and ability of this equipment. Microscope which is frequently used in science education is one of such tools. Microscope usage information is very important for a science educator. Therefore, a teacher who acquired this information and usage ability will be effective in encouraging students to use the microscope correctly, to have interest in science and even to do research in this field. In parallel with this importance, it is thought that the science educators who study in faculties need to have a good ability of microscope usage information. Based on this expectation, the aim of this study is to identify the ability of microscope usage information of the candidate students who study at science teaching department in 2nd grade. This study has been conducted with 80 2nd grade students who study in science teaching department of a university in Black Sea region of Turkey. Microscope usage information scale which was improved by Benzer and Demir in 2014 has been used as obtainment tool in the study. Microscope usage information scale is composed of tripple likert type 20 articles and two open-ended questions. The data which were obtained from likert type articles have been evaluated with frequency calculation whereas the data which were obtained from open-ended questions have been evaluated with content analysis. According to Büyüköztürk et al. (2008), content analysis is defined as a systematic technique where certain words of a text are summarized with smaller content categories through coding. Based on the results that were obtained in the study, interpretations have been made and suggestions have been offered in order to enlighten other researchers.

**Key words:** Microscope usage information, teacher candidate, science education

## INTRODUCTION

The innovative age we live in presents us with various technological products and new ideas. Each new idea leads to the development of a new product. In our age making creative thinking a necessity, it is considered vital to use the existing information and technology in an eligible and equipped manner to create innovative ideas. In that sense, sciences and having an accurate outlook on sciences have been gradually gaining more and more significance. Science does not only include technological thinking and application skills, but also makes laboratory usage and skills necessary. In science education, laboratory and the perspective on laboratory are of great importance. Laboratories, which can be considered as the fundamentals of science and its effective use bring out qualified teacher skills. In science education, laboratories are considered as environments, which almost make it necessary to minimize memorized knowledge. Laboratory works include students into the learning and discovery process via firs hand experiences and enable them to participate in scientific activities to ask questions, propose solutions, make assumptions, organize data, explain examples etc. (Kanlı and Yağbasan, 2008). Laboratories possess an uncontroversial place in the science education. One of the most effective methods in the science education is laboratory method (Hofstein, Kipnis and Kind, 2008; İlhan, Sadi, Yıldırım and Bulut, 2009; Demirbaş and Pektaş, 2010; Dahar and Faize, 2011). As a result of the nature of science, laboratories are considered as the only environment, where many high-level skills such as researching, investigating, and interpreting can be gained, developed and were applied activities and experiments can be conducted. As a matter of fact, it is stated that science courses must be completely instructed in laboratories or the classrooms must be organized as laboratories (Bahar, Aydın, Polat and Bertiz, 2008). Especially, open ended laboratory experiences enable students to criticize generally misunderstood conceptions through their intuitions and to look for creative solutions (MacLean, 2003). Many previously conducted studies have revealed that laboratory method is quite an effective method in science education (Lawson 2005). Laboratory activities require various materials, which are either simple or complicated, from everyday life to be used together (Güler and Çobanoğlu, 1997). The laboratory studies allow for scientific thinking, developing a positive attitude towards science and scientific applications, acquiring scientific process skills, and learning science subjects through living and experiencing them in a better manner (Harman, 2012). Laboratory materials cause students to structure scientific information by working like scientists and to obtain scientific habits (Jewitt, Kress, Ogborn, and Tsatsarelıs, 2001). In that sense, laboratories can be defined as the kitchen of science.

One of the biggest challenges the scientists, who focus on the field of experiment and observation, used to face with was the limitedness of sense organs. In overcoming this challenge, one of the two magical devices related to lenses was telescope, which enabled zooming from far distances, and the other one was microscope, which enabled focusing on very small areas (Evrim, 2011). In the study, they conducted, Flick and Bell (2000) has stated the significance of teachers' use of microscope for scientific and technological purposes. "Microscope" is one of the most significant tools, which makes it easier for students to learn conceptions related to the field of biology (Ekici, 2016). Microscope can be defined as "An optic tool consisting of lens systems, which enable the examination of living and non-living objects that are not macroscopic'' (Özata and Türe, 1999; Dökme, Doğan and Yılmaz, 2010; MEB, 2011). Thus, microscope is of importance in terms of making objects, which are abstract and cannot be seen with bare eyes, become visible. Microscope, which are available in most of primary education schools (Akpınar and Turan, 2002; Demir, Böyük and Koç, 2011) is a material, which makes understanding easier when used in education just like other technological tools (Yavuz and Coşkun, 2008). In their study, in which Şimşek, Hırça and Coşkun (2012) examined the teaching methods and materials used by science and technology teachers, they have stated that the science and technology teachers prefer conventional method such as question-answer and plain instruction, instead of methods such as actively including students into the process of learning and conducting activities such as using microscope, computer, project works, which help with improving students' scientific research skills. For this reason, it is believed that both teachers and prospective teachers should be qualified enough at microscope use. In fact, in the study conducted by Ural Keleş, Er Nas and Çepni (2009) it was also observed that prospective teachers had misconceptions at the stage of forming an image on a microscope. In that context, it is believed that prospective teachers should spend more quality time with microscope. In the study carried out by Yeşilyurt (2004), it has been revealed that prospective teachers have difficulty with understanding when they are less occupied with microscope. The results of the research conducted by Demir (2015) suggest that the microscope usage knowledge of prospective science teachers is usually at an intermediate level, which is deemed insufficient.

Considering all of these studies, it is assumed that it is of importance and necessity to find out whether prospective teachers have a competent use of microscopes or their level of microscope usage. Hence, the aim of this study is to detect the microscope usage knowledge of the prospective teachers, who are second year students at the department of science teaching.

## METHODOLOGY

In this study, survey model has been used, since the aim of the research is to describe the microscope usage knowledge of prospective students, who study at the department of science teaching, through a measurement instrument and open-ended questions. It can be asserted that the studies in survey model describe, explain, and reveal what has been experienced and who has experienced them (Sönmez and Alacapınar, 2011).

This study was carried out with 80 second year students, who study at the science teaching department of a university in the Black Sea region of Turkey. In this research, the microscope usage knowledge scale, which was developed by Benzer and Demir in 2014 and validity and reliability which have been studied, was used as the data collection tool. This scale was applied to 273 prospective teachers in total, who were 1st, 2nd, 3rd, and 4th year students studying at the Department of Science Teaching, by the researchers. This scale developed by the researchers consists of sub-dimensions such as examining the image, technical knowledge and terms, sectioning, and the sectors in which microscope is used. The scale includes 23 items, to which students can answer give answers such as yes, no, or I do not know, and two open-ended questions, to which they answered by providing explanations.

In this research, the data obtained from the likert type items included in the scale were analyzed through frequency count; the data retrieved from the open-ended questions were analyzed through content analysis. According to Büyüköztürk et al. (2008), content analysis can be defined as a systematical technique, in which some words in a text are summarized in smaller content categories through coding.

## FINDINGS

In this study, data obtained from the microscope usage knowledge scale were used. The data obtained from the scale were gathered and interpreted under three headings: "Percentages Obtained from Scale Items", "Themes about all of the Stages Required to Examine a Plant Tissue through a Microscope", and "Other Expressions Uttered by Prospective Teachers".

**Table 1.** Percentages obtained from scale items

| Some items about the scale | yes | no | I do not know |
|---|---|---|---|
| 1-Macroscrew helps with clarifying the image. | 45 | 53.8 | 1.3 |
| 2-In order to examine something with microscope, firstly the tray is lifted and preparate is placed. | 10.0 | 87.5 | 2.5 |
| 3-Diaphragm may be opened or closed based on the work to be performed. | 65.0 | 22.5 | 12.5 |
| 4-The section taken from the plane, which is vertical to the long axis of the material, is transversely cut. | 87.5 | 10.0 | 2.5 |
| 5-In general, there are three types of sectioning including transverse, longitudinal, and superficial sectioning. | 95.0 | 5.0 | 0.0 |
| 7-While examining on microscope, 4-objective image is used for drawing. | 25.0 | 67.5 | 7.5 |
| 8- It is necessary that macroscrew is not touched in 4-objective. | 18.8 | 73.8 | 7.5 |
| 10-Glass slide and cover glass are called preparate. | 21.3 | 76.3 | 2.5 |
| 11-In order to examine something with microscope, the objective is checked, preparate is placed and lastly tray is lifted. | 88.8 | 7.5 | 3.8 |
| 12-The image on the microscope must be exactly drawn, and be verified through obtaining information. | 95.0 | 5.0 | 0.0 |
| 13-The image in the microscope must be drawn in detail, just like those in the books. | 43.8 | 43.8 | 12.5 |
| 14-Miscroscope is used in the health sector. | 86.3 | 10.0 | 3.8 |
| 15-It is okay to play with the macroscrew in 40-objective. | 20.0 | 70.0 | 10.0 |
| 17-Diaphragm is on the microscope tray. | 21.3 | 72.5 | 6.3 |
| 19-Microscope magnification is written as "objective x ocular". | 85.0 | 5.0 | 10.0 |
| 20-Examination environment refers to the solution dripped to get a better view of the taken section. | 50.0 | 35.0 | 15.0 |
| 22-Microscope is used in criminal offenses. | 78.8 | 2.5 | 18.8 |
| 23-In order to examine something with microscope, without checking the objective, the preparate is placed and the tray is lifted. | 11.3 | 85.0 | 3.8 |

Examining the Table1 , it is apparent that the prospective teachers gave positive answers to many items such as *"The section taken from the plane, which is vertical to the long axis of the material, is transversely cut; In order to examine something with microscope, firstly the tray is lifted and preparate is placed;* In general, there are three types of sectioning including transverse, longitudinal, and superficial sectioning", whereas; they were in contradiction especially with the following items: *"Macroscrew helps clarifying the image; and The image in the microscope must be drawn in detail, just like those in the books"*.

**Table 2.** Themes about all the required stages to examine a plant tissue through a microscope

| Themes | yes | no |
|---|---|---|
| Correct sorting | 43.8 | 56.2 |
| Full examination | 3.8 | 96.2 |
| Creating the correct preparate | 71.3 | 28.7 |

When expressions obtained from the prospective teachers' writings of all the required stages to examine a plant tissue on a microscope, Table 2 suggests that the correct sorting theme was mostly accomplished, yet it was still almost equally distributed; the full examination theme was not accomplished for the most part; and the theme of preparing correct preparate was mostly accomplished.

Table 3 suggests that the other expressions most frequently uttered by the prospective teachers include *"It should be held from under, not be dragged; When the operation is done, it should be adjusted to 4x10 objective; Firstly, it is at 4-objective; In other objectives, the image is clarified without touching the macroscew; When the examination is completed, preparate is taken and microscope is turned off; Microscrew clarifies the image; When the operation is completed, the tray must be put down"*.

**Table 3.** Other expressions uttered by prospective teachers

| Expressions | f |
|---|---|
| It should be held from under, not be dragged | 6 |

| | |
|---|---|
| When the operation is done, it should be adjusted to 4x10 objective | 4 |
| Firstly, it is at 4-objective. | 3 |
| In other objectives, the image is clarified without touching the macroscew. | 3 |
| When the examination is completed, preparate is taken and microscope is turned off. | 3 |
| Microscrew clarifies the image. | 2 |
| When the operation is completed, the tray must be put down. | 2 |
| When the operation is over, it should be picked and cleaned. | 2 |
| We should be careful not to break the preparate. | 2 |
| Other | 26 |

## RESULTS

The constructivist learning theory, which places the student in the center of learning, puts emphasis on the necessity and importance of providing students with a setting, where they can research, associate the information they learn with their everyday life in order to obtain in-depth knowledge (Çinici, Sözbilir, Demir 2011). Many science educators have stressed on the importance of laboratory activities in achieving success at science and developing positive attitude towards since as well as on the significant effect of laboratory activities (Renner, Abraham and Birnie, 1985; Roth, 1994; Okebukola, 1986; Shymansky and Kyle, 1988; Hofstein and ark. 2005; Renner, 1986). In the laboratory setting, students should design their own experiments by themselves, create and test their own hypotheses, determine the variables of the experiment by themselves, decide what data to record by themselves, draw tables on their own, make conclusions; in short, the students should participate in activities that will improve their scientific process skills and they should not spend effort to exactly and passively fulfill the duties assigned to them by a teacher or written on a laboratory sheet (Kanlı and Yağbasan, 2008). Laboratories make students active during learning, increase their curiosity in research, and lead them to think creatively (Büyükkaragöz and Çivi, 1996). Thereby, through laboratory activities the individuals' improvement of scientific process skills will be supported, thus knowledge will be created.

Direct teaching can be defined as teacher's creating knowledge by guiding students throughout a number of activities such as experiment designing, learning via using microscope, performing measurement etc. (Schroeder, Scott, Tolson, Huang and Lee, 2007). The constructivist learning is the learning philosophy, in which student is made active and learning occurs through living and experiencing. In order to realize the expected objectives of this field, it is essential to make the best use of laboratories and course materials-tools (Köseoğlu and Soran, 2006). Considering the results of the study carried out by Keskin, Özbek, Ulaş, and Müdok (2015), it is apparent that the students of our age, who grow up with technological improvements, mostly prefer digital microscope usage and work more comfortably with these images. The microscope usage includes a process, which requires experience. In the study conducted by Uzel et al. (2011), it was found out that ocular, tray, macroscrew, and microscrew are the components, which prospective science teachers accurately recognize; and condenser screw and condenser are the components inaccurately recognized by the prospective teachers. In this study, it was found out that the prospective teachers gave positive answers to many items in the scale; however, they were in contradiction with the following items "Macroscrew helps clarifying the image; and the image in the microscope must be drawn in detail, just like those in the books". In the study conducted by Uzel et al. (2011) regarding examining the image on the microscope, it was revealed that the prospective science teachers had difficulty with sectioning. When expressions obtained from the prospective teachers' writings of all the required stages to examine a plant tissue on a microscope, it is observed that the correct sorting theme was mostly accomplished; the full examination theme was not accomplished for the most part; and the theme of preparing correct preparate was mostly accomplished. In that sense, it is apparent that the prospective teachers do not have difficulty with creating preparate; however, they cannot conduct a full examination. Again, in this study it was observed that the most frequently uttered expressions by the prospective teachers include "It should be held from under, not be dragged; When the operation is done, it should be adjusted to 4x10 objective; Firstly, it is at 4-objective; In other objectives, the image is clarified without touching the macroscew; When the examination is completed, preparate is taken and microscope is turned off'. Examining the codes about capturing an image on microscope and examination touch in the study conducted by Benzer and Demir (2014), it is seen that the 3rd year students had the highest number of correct answers to capturing and clarifying an image codes; the 2nd and 4th year students had approximately same number of correct answers; 1st year students had no knowledge about this subject at all. In their study, Taşdelen and Güven (2012) found out that the prospective teachers wanted more experimental activities to be conducted and the observations to be performed by using microscopes.

In the laboratory activities at school, it is possible to enable student to obtain experience about learning through discovery by allowing them to use microscope (Puckering et al., 2003). In the study carried out by Dikmenli, Türkmen and Çardak (2002), the alternative conceptions of undergraduate science department students about microscope activities in the biology laboratories were found out; in the research conducted by Ekici (2016), metaphors and explanations, uttered by prospective biology teachers about microscope, which were quite rich, meaningful and had different perspectives, were discovered. It is accepted that microscope usage has an essential place in science education. That's why, it is deemed necessary for a science educator to possess enough level of knowledge on microscope usage and technical information about microscope. Thereby, it is believed that science educators will be effective at enabling students to bring nature to the laboratory and discover some invisible and unknown structures, organisms, and objects (Demir, 2015). Also, Ketelhut, Nelson, Clarke and Dede (2010) discuss that even through virtual microscopes it is possible for students to feel as if they are actively conducting an experiment and feel like a scientist. Detecting what the misconceptions about microscope are and re-arranging biology and biology laboratory activities in order to decrease or terminate these misconceptions are of utmost importance in increasing the success level of students (Yeşilyurt, 2004).

According to Doğan et al. (2003), students should be given a course on biology laboratory usage, in which they can acquire laboratory usage skills. The students should be given the opportunity to use the laboratories besides their course hours. Books, which are mostly visual, about laboratory lessons should be prepared. Students' motivation should be increased; thereby they should be enabled to come prepared to the laboratories. Some changes should be made in the curriculum of the laboratory courses; the number of experiments, which are applicable and can be conducted with basic materials, should be increased. Moreover, laboratory education should be attached importance in terms of improving innovative thinking skills in the field of science. With its setting, education, and materials, the laboratory happens to be an area, regarding which especially prospective science teachers should improve themselves. Thus, it is believed that the prospective science teachers should improve themselves about microscope usage and experiments and make the best use of each opportunity. Microscope is a tool, which does not only improve students' thinking, research, examination, comprehension, observation etc. skills in the laboratory activities, but also enables obtaining images by concretizing the prepared objects according to certain rules, usually with the help of teachers (Basey, Mendelow, and Ramos, 2000). In fact, Ekici (2016) also states that it is important to pay a special importance to microscope usage at all stages of education from primary school to university. That's why, it is believed that in order to improve microscope usage skills of the prospective teachers, they have to experience quite enriched experiment environments.

## SUGGESTIONS

Considering this study:

1. It is believed that, especially in undergraduate programs, the subjects with biology content should be instructed by using microscope as much as possible, in an applied manner.
2. Also, it of high importance for the prospective teachers studying these programs to experience as many sample activities as possible.
3. The students studying this program must possess knowledge and skills about microscope usage in order to enable especially prospective science teachers to practice their profession in a qualified manner in future and enable primary and secondary school students to efficiently use microscope.

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# INTERACTION OF GENOTYPE AND ENVIRONNMENT IN EXPRESSION OF PHENOTYPE: DO UNIVERSITY STUDENTS INTEGRATE KNOWLEDGE ABOUT EPIGENETICS

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**ABSTRACT:** In recent decades, genetic issues play a large role in health and public policy and new knowledge in this field continues to have significant implications for individuals and society. In spite of this increased exposure to genetics, recent studies of the general public's genetics knowledge show a relatively low understanding of genetics concepts. Epigenetics is a new paradigm in biology. Nevertheless, the notion of genetic determinism is still present in syllabuses and textbooks. The present research explores the university students' conceptions related to the genetic determinism of behaviors and human performances and if they integrate recent knowledge in Epigenetics. The research method is a questionnaire elaborated by the Biohead-Citizen consortium. The findings revealed that these students were still reducing the biological identity to a genetic program. The set can also enhance the danger of hereditarian ideology that justifies the fatalism and racism. We concluded that the teaching of epigenetics becomes a scientific and citizen challenge.

**Key words**: Genetic determinism, students, conceptions

## INTRODUCTION

In the twentieth century, the nature-versus-nurture debate was one of the most important themes of genetics (Castera et al, 2008). Now, most scientists accept that both factors have a crucial role and that phenotypes result from the actions and interactions of both, which often change over time (Petronis, 2010). Most phenotypes show some degree of heritability, a finding that formed the basis for a series of molecular studies of genes and their DNA sequences (Nicol-Benoit et al, 2013). In parallel to such genetic strategies, thousands of studies have been carried out to identify environmental factors that contribute to phenotypes (Georgel, 2015). The new paradigm is not one of nature versus nurture, but of a complex and dynamic interaction between DNA sequence, epigenetic DNA modifications, environment, gene expression, and environmental factors that all combine to influence phenotype (Gibson, 2008; Kilpinen et Dermitzakis, 2012).

Over the last years, several university programs introduced bit by bit epigenetics as part of the genetics (regulation of the expression of multiple genes, cell differentiation…). However, in most countries, university programs of Biology do not include the wealth of information gathered over the last 30 years of investigation of epigenetics. This article aims to explore if the students integrate the recent scientific knowledge about Epigenetics when they are asked about relationship between Genotype and environment in expression of phenotype. The article also tends to identify their conceptions related to the genetic determinism of behaviors and human performances.

## THEORETICAL BACKGROUND

### The Genotype-Phenotype Relationship

The Genotype, carried by all living organisms, holds the critical instructions that are used and interpreted by the cellular machinery of the cells to produce the "outward, physical manifestation", or Phenotype of the organism. Thus, all the physical parts, the molecules, macromolecules, cells and other structures, are built and maintained by cells following the instructions given by the genotype. As these physical structures begin to act and interact with one another, they can produce larger and more complex phenomena such as metabolism, energy utilization, tissues,

organs, reflexes and behavior; anything that is part of the observable structure, function or behavior of a living organism (Braun, 2015).

The genotype of a cell is its genetic makeup while the phenotype encompasses its traits, such as morphology and function. Genotype and phenotype represent two separate cellular entities; while the former is the structure of the genome-the DNA sequence, the latter is the determination of the form, growth and interactions with the external world of the cell. It can be any observable property of the living organism.

The establishment of a phenotype, given a certain genotype, depends on the protein makeup of the cell. The set of expressed proteins, a subset of the entire genome potential, and their concentrations, are determined by regulatory systems at many levels. Thus, the emerging phenotype depends on the spectrum of regulatory modes-temporal profiles of expressed genes. However, a snapshot of the molecular content of a cell and the structure of its underlying interactions do not capture the spectrum of regulatory profiles that define the relevant observables that determine the phenotype (Braun, 2015).

The protein content of each isolated gene is by itself not such a relevant observable. Therefore, inquiring into the genotype-to-phenotype associations requires a shift in focus from structure to dynamics, from the molecular stuff of the cell to its temporal organization. The genotype-to-phenotype mapping is largely assumed to be deterministic in nature, accompanied by 'noise' by environmental influences and intracellular stochastic processes due to the small volume of the cell and the small number of molecules involved (Braun, 2015).

**Epigenetics**

Epigenetics has become a topic with implications across a diversity of biological disciplines, inspiring exciting theoretical and empirical work. The term dates back to the work of Waddington in the 1940s who was one of the earliest researchers to disavow a simple relationship between genotype and phenotype. Since that time, interpretations of the term have evolved, particularly as molecular-level mechanisms that modulate gene expression have been revealed. Still, even since Waddington, the term has been used to refer to the interactions of the genome with the internal and external environment in the production of phenotypes (Richards, 2012).

Prior to the middle of the twentieth century, before DNA was given a special status in biology, the developmental biologist and evolutionist Waddington (1905-1975) emphasized that genetics and developmental biology were related, hypothesizing that patterns of gene expression, turning genes on and off, and not the genes themselves, define each cell type, thus linking genes and gene action to development. To denote the dynamic actions leading from the genotype to the phenotype, Waddington coined the term 'epigenetics' from the Greek word epigenesist, referring to embryology and genetics as "a gradual coming into being of newly formed organs and tissues out of an initially undifferentiated mass". In this way, Waddington indicated that an epigenetic landscape underlies each developing organism, referring to the existence of a complex network in which genetic interactions, the feedback and "feedforward" relationships among DNA, proteins, and other internal and external biochemical compounds are highly intermingled. Riggs (1975) proposes a molecular model for the switching of gene activities, and also the heritability of gene activity or inactivity. This model was based on the enzymatic methylation of cytosine in DNA. The suggestion was that DNA methylation could have strong effects on gene expression, and changes in DNA methylation may therefore explain the switching on and off of genes during development, and that the pattern of methylation could be heritable, persisting through cell divisions (Barros & Offenbacher, 2009).

Epigenetics, as the term suggests, can be seen as a major turn away from molecular biology's Central Dogma, recognizing that there are epigenetic inheritance systems through which no sequence-dependent DNA variations can be transmitted in cell, tissue, and organismal lineages (Barros et Offenbacher, 2009).

**Models of Genotype-Phenotype Relationship**

The concept of phenotype, which corresponds to the observable attributes of an individual, was coined in opposition to the genotype, the inherited material transmitted by gametes. Since the early proposal that genotypes and phenotypes form two fundamentally different levels of biological abstraction, the challenge has been to understand how they articulate with each other, how genotypes map onto phenotypes.

***Linear Causal Model***

From a genetic change causing a variation in phenotype, it is often convenient to assimilate the corresponding gene as a causal determinant of a trait (Figure 1a). It is common to find headlines expressing these simplifications,

trumpeting to wide audiences the discovery of the "aggressiveness" or "intelligence" gene. According to this model a variation at a given gene causes variation in a given phenotype (Waters, 2007).

The genetic reductionist approach, which only explores a few genetic parameters among the variety of causal factors, is vain to fully address the broad question of what brings forth a particular biological structure or process in its entirety. Nevertheless, genetic reductionism can be perfectly appropriate for identifying genetic loci where a change causes a phenotypic difference (Orgogozo et al 2015).

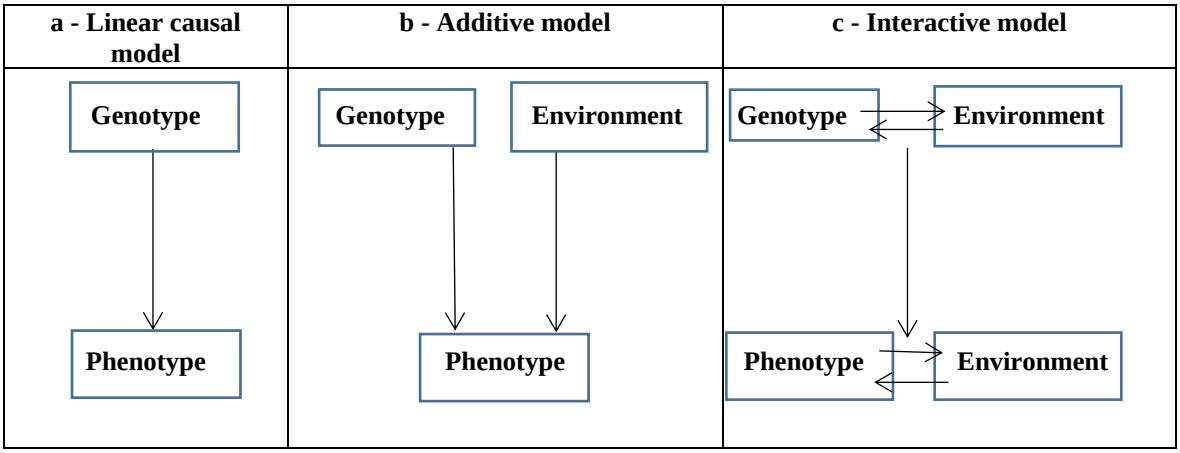


**Figure 1.** Different models of genotype-phenotype relationship

***Additive Model***

In fact, a gene alone can neither cause an observable phenotypic trait, nor can it be necessary and sufficient to the emergence of observable characteristics. Genes need a cellular environment, the combined action of multiple other genes, as well as certain physico-chemical conditions to have an observable effect on organisms. The expression of the phenotype results from the additive action of effects of genotype and environment (Figure b).

***Interactive Model***

Gene-by-Environment (GxE) interaction occurs when the phenotypic effect of a given genetic change depends on environmental parameters. Similarly, epistasis, or GxG interaction, occurs when the phenotypic effect of a given genetic change depends on the allelic state of at least one other locus (Hansen, 2013). There is increasing evidence that GxG and GxE interactions are of fundamental importance to understand evolution and inheritance of complex traits ( Hansen, 2013). Both phenomena can be integrated into the basic GP differential framework, where both GxG and GxE interactions inject a layer of context-dependence, and result in differences embedded within differences (Orgogozo et al 2015).

In summary, in presence of epistasis or GxE interactions, a genetic change is not associated with a single phenotypic difference but with multiple possible phenotypic differences, among which one will be achieved, depending on the environment and the genetic background. The context-dependence can be represented schematically as GP differences embedded into other genotype and environment differences (Orgogozo et al 2015).

As underlined by multiple authors (most notably Waddington, 1957; Keller, 2010), genes and environment act jointly on the phenotype, and in most cases, it is impossible to disentangle the effect of one from the other. Here we show that reasoning in terms of differences helps to clarify the comparison between genetic and environmental effects on phenotypes. However, we identify certain cases where the comparison remains difficult (Orgogozo et al 2015).

Understanding of an organism's ability to respond to its environment has advanced dramatically during the last few decades, in large part through studies controlling for genotypic variation and manipulating environmental factors. These studies typically confirm not only that genotype and environment contribute to phenotypic variation but also that these two factors interact; that is, different genotypes often respond differently to environmental variation (Richards 2010). (Figure c).

**Nature Versus Nurture: Genetic Determinism**

The 'nature versus nurture' debate is an old, traditional but outdated discussion. All biologists consider today that any phenotype emerges from the interaction between the genome (nature) and its environment (nurture). Working on this interaction is a new trend of biology, called 'epigenetics'. Consequently, the traditional debate of genes 'or' environment, or '% of genes and % of environment' (which is possible only for an additive model 'genes + environment'), is outdated because there is an interaction between genes and environment. Genetic determinism is not sufficient to explain the complexity of human phenotypes. Only the multiple interactions between genome, environment and organism can give an overview of the biological complexity. Genetic determinism explanations can be used as a justification for social fatalism, with political or religious issues (Castera & Clement, 2014).

On another hand, several authors have developed critical analyses of innatism (Atlan 1999, Jacquard & Kahn 2001). They proposed a synthesis by distinguishing four forms of innatism: The first one claims that there would be inherited biological differences in mental abilities between individuals within each human group. The second postulates such differences between racial groups. The third claims that social structures and behaviors would reflect the weight of genetic factors. The fourth form of innatism considers the belief that mental gender differences would be genetically determined. Beliefs in strong genetic determinism engender intolerant attitudes. (Castera & Clement, 2014).

## METHODS

This study is mainly qualitative, our methodology was mixed. We used a questionnaire and interview. These qualitative analytical methods were supplemented with statistical analysis to identify students' misunderstanding in Epigenetics.

**Students Sample**

All the students surveyed in the study were enrolled in a graduate science program at the University, the sample is composed of 86 Graduate Students (baccalaureate plus 3 years of study) and 20 Master' students (baccalaureate plus 4 or 5 years). Females comprised 46 percent of the sample.

**The Questionnaire**

We composed a questionnaire to acquire information on several key issues: (a) the students' understanding of Epigenetics and interaction between Genotype and Environment in expression of the phenotype (b) the students' conceptions of the genetic determinism of human performances (Table 1). Some of the questions were inspired by previous studies especially those relating to the genetic determinism of behavior and intellectual performance (Clement et al, 2006). However, we developed many new questions appropriate for students at the graduate level.

The responses to all the questions about genetics are based on a Likert scale on which each teacher was asked to tick one of four boxes, ranging between 'I agree' and 'I don't agree'. The majority of the questions concern genetic/biological determinism of human behavior. These questions can be grouped into four different categories: (1) Genetic determinism of personal or individual features: questions about clones and twins (A3, A6, A19, A24, A43 and A53). (2) Genetic/biological differences related to gender (A9, A14, A21, A25, A36, A38 and A46). (3) Genetic determinism of human behavior (B8, B10, B14 and B20).

**Table 1.** The 16 questions related to biological (mainly genetic) determinism (their ranking throughout the whole questionnaire is stochastic).

| | Question | I agree | | | | | I don't agree |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A3. | If clones of Einstein could be obtained, they all would be very intelligent. | | | | | | |
| A6. | Due to identical genes, identical twins have identical immune responses to transplants from another person. | | | | | | |
| A9. | Women are less intelligent than men because their brains are smaller than men's brains. | | | | | | |
| A14. | Thanks to their physical features, men perform better in athletics than women. | | | | | | |
| A19. | Due to identical genes, identical twins have identical brains and, therefore, identical behavior and ways of thinking. | | | | | | |
| A21. | women can be as intelligent as men Biologically | | | | | | |
| A24. | If clones of Mozart could be obtained, they all would be excellent musicians. | | | | | | |
| A25. | It is for biological reasons that women cannot hold positions of high responsibility as men can. | | | | | | |
| A27. | The human genome contains more genes than the genome of any other living being. | | | | | | |
| A31. | When a couple has already had two girls, the chances that their third child will be a boy are higher. | | | | | | |
| A35. | Ethnic groups are genetically different and that is why some are superior to others. | | | | | | |
| A36. | Men might be more able to think logically than women, because men might have different brain bilateral symmetry. | | | | | | |
| A38. | It is for biological reasons that women more often than men take care of housekeeping. I | | | | | | |
| A43. | In identical twins, one can be right-handed and the other left-handed. | | | | | | |
| A46. | Biologically, men cannot be as sensitive and emotional as women | | | | | | |
| A53. | Due to identical genes, identical twins have identical immune responses to microorganisms. | | | | | | |

**The Interview**

Interview was conducted on six students. The interviews lasted approximately 30 minutes. Thematic interview questions are used to explore in greater detail the most commonly held misconceptions identified by the questionnaire analysis.

## RESULTS AND DISCUSSIONS

More than six students out of ten states that the phenotype is determined solely by the genotype (62%) and that the action of the environment on the phenotype requires a change in the DNA sequence (60 %). This reflects that a majority of students don't know epigenetic mechanisms. This is confirmed by the fact that more than the half of them state that chromatin is a DNA carrier and is not involved in the expression of the phenotype (58%) (Table 2).

**Table 2.** Students' responses related to genotype-phenotype relationship (in %)

| Responses in % | I strongly agree | I rather agree | I rather disagree | I strongly disagree | I don't know |
|---|---|---|---|---|---|
| The phenotype is determined solely by the genotype | 35 | 27 | 13 | 11 | 14 |
| The action of the environment on the phenotype requires a change in the DNA sequence | 42 | 18 | 14 | 17 | 9 |
| Chromatin is a DNA carrier and is not involved in the expression of the phenotype | 35 | 23 | 9 | 12 | 21 |
| DNA methylation / demethylation is a signal for activation or deactivation of a gene | 27 | 25 | 16 | 9 | 23 |

One student out of two state that DNA methylation / demethylation is a signal for activation or deactivation of a gene (52%).

In the interview, we identified a common perception held by the students which stipulates that genes, as units of information controlling various traits, are distinct and totally separate from the environment (Figure 2). This perception is certainly true of the physical-structural- chromosomal entity called gene, but it does not apply to genes as units of information or function. The notion that information resides in the genes and that the environment simply provides the medium through which information is displayed is incorrect. The only sure evidence of epigenetic inheritance involves methylation of genes through which identical genes coming through the two parents can behave differently in their expression (Singh, 2015; Agorram, 2010).

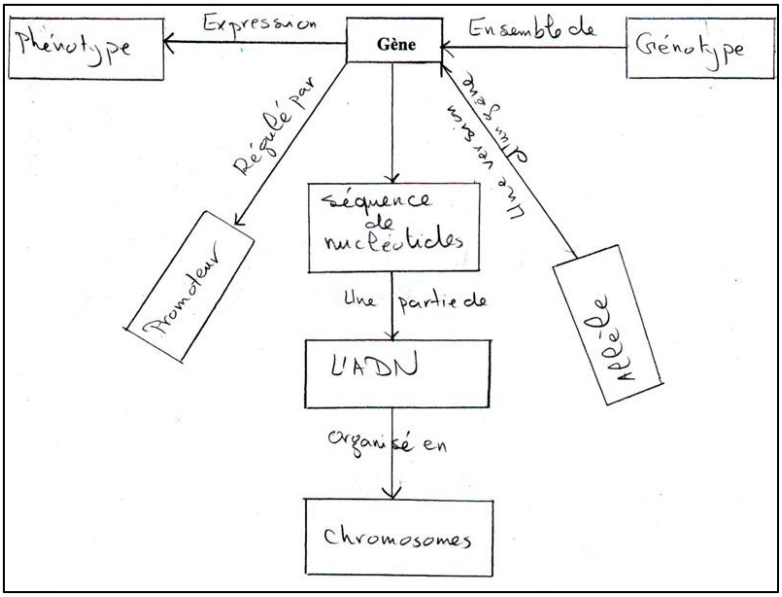


**Figure 2.** An example of students' responses about gene-phenotype

About half of the students surveyed say that similarity of the reactions to different factors (immune response to micro-organisms and to transplantation) or similarity of behaviors of identical twins is due to the identity of their genes (Figure 3).

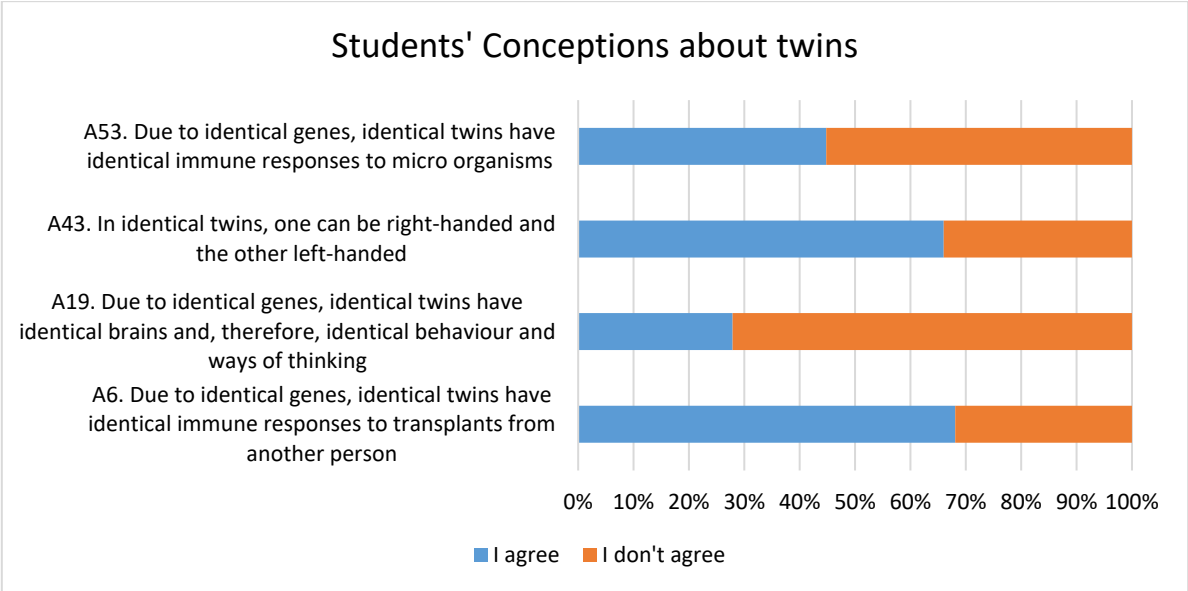


**Figure 3.** Students' responses about genetic determinism among twins

It is generally agreed that epigenetics provides sufficient flexibility and latitude to the developmental program of a given genotype such that even identical twins become "unidentical" as they proceed through life (Haque et al, 2009).

Numerous studies show that it is clear that identical twins have substantial differences in obvious phenotypes like disease, and in epigenetic DNA modification patterns. Earlier twin studies were based on the premise that

monozygotic twins are genetically identical, and that phenotypic differences must arise from no shared environment. However, knowledge of epigenetic mechanisms such as differential DNA methylation, skewed X-inactivation, and imprinting provides a new model to understand monozygotic twins' discordance (Gibson, 2008; Bhalla & Iyengar, 1999).

We notice that some of the students think that the differences between men and women (intelligence, sensitivity) are due to biological and genetic factors. Women are biologically different from men; these differences make them suitable for some household activities but that make them less able to do other activities. According to these students, the difference in behavior of men and women is due to the identity of their genes (Figure 4).

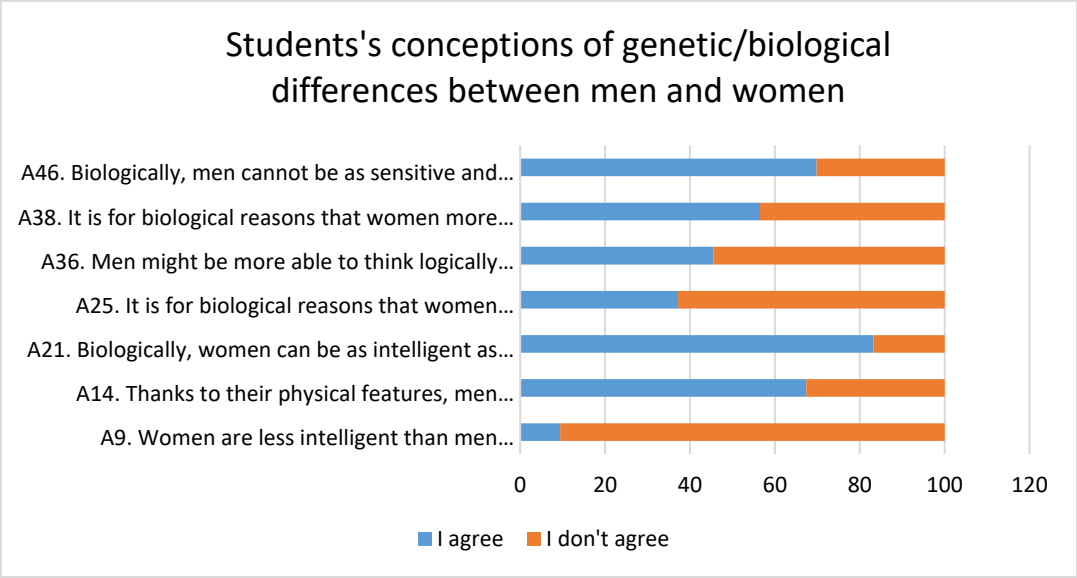


**Figure 4.** Students' responses about genetic/biological causes of differences related to gender

Genes determine all of characteristics, and different traits (as to be alcoholic, good in school, aggressive…) were inherited from parents. This misconception was found among more two students out of ten (Figure 5). It's sure that genes play a huge role in how an organism develops, but environmental factors also play a role and some heritable changes occur without changes in the genome. Many studies showed that gene expression in identical twin changes from environmental factors and suggested that these changes can accumulate over the life of the organism. It is possible that these behaviors have a genetic component, but they are not governed by genes alone, there is an interaction between genes, environment, and epigenetic factors.

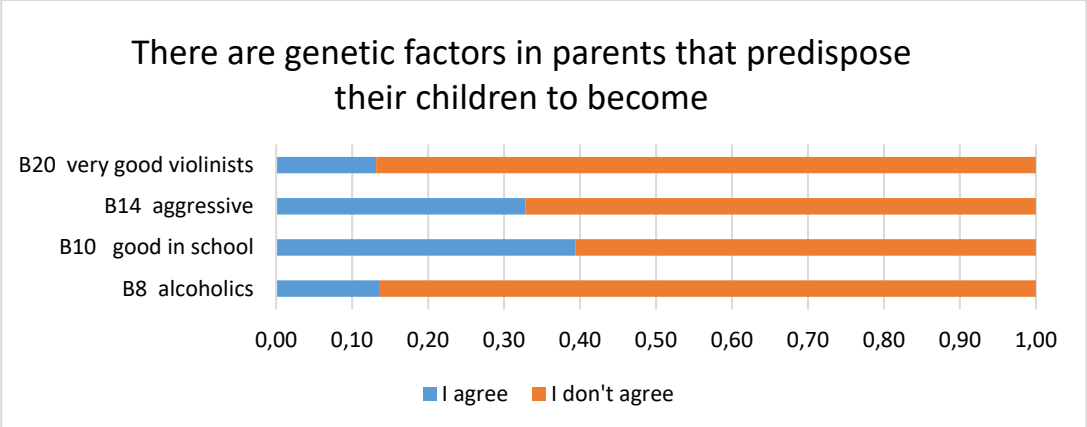


**Figure 5.** Students' responses about heredity of some behaviors and intellectual performances

## CONCLUSION

Either cellular or macroscopic phenotype is ultimately based on the properties of synthesized proteins. Now these are the genes which code proteins responsible for the phenotypic characters. So, we would think that there is a linear relationship between a gene and a character, the first determining the second. In fact, the relationship between genotype and phenotype are often more complex.

This complexity of life cannot be reduced to a single genetic determinism. Its study needs to compete with other epigenetic, mechanisms to analyze the construction of phenotypic traits. New models (based on the concepts of self-organization, collective intelligence) contribute significantly to this change in perspective (Petronis, 2010).

The analysis of students' responses related to the genetic determinism of human features, behaviors or performances shows a clear innatism in a majority of students' answers. Moreover, this innatism is partly correlated to some sexist and even racist answers. This conclusion is illustrating interactions between the taught science (the scientific knowledge K) and implicit values (V) (Clement, 2006).

Epigenetics is still absent from university education programs reflecting an important didactic transposition delay. In the next few years, our understanding of the multiple layers of genomic information is likely to improve significantly. The school must incorporate these scientific innovations quickly enough and especially when they have an important educational dimension and which are related to socially controversial problematics.

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# THE USE OF EDIBLE SCIENCE PROJECTS IN TEACHING SCIENCE CONCEPTS

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**ABSTRACT**: Students have difficulty in learning the concepts of science and similarly teachers have difficulty in teaching the concepts of science. In order to overcome these difficulties, different teaching methods are tried and it is attempted to attain success. Educators usually study the question of "how can we provide an easier and more permanent teaching?" As a solution to this problem they agree that activities which draw the attention of the students and which the students get pleased and entertained while doing enable the effective learning in teaching the concepts of science. In this regard project-based learning is one of the effective methods. However, it is not often preferred by the teachers due to the problems in the supply of materials and being long-term activities. Thus, primarily students were made to experience a scientific process by using the processes of project-based learning and a method which had an easy and cheap material supply was used in the study. By using the materials which everyone could buy easily and in a cheap price, senior students of Education Faculty were made to do edible projects. For these projects, students were divided into groups of two people and each group modelled a concept of science that they chose themselves by using edible materials such as sugar, cake, chocolate, pasta. In total, 15 groups of two people developed 26 different projects. These projects were mostly made by using the concepts of science such as cell, DNA, RNA, mitosis and meiosis, brain, atomic models, periodical table, planets, solar system and earth's crust. These projects were later exhibited and they were introduced and presented to the other students in the Faculty. It has been observed that the students' awareness for the concepts of science increased while the projects were being done and exhibited. It has been observed that this presentation drew attention as students tasted the models and shared them with the other students. It is quite important that these projects are introduced and published in order to popularise the use of such projects in all levels of teaching. For this purpose, it is aimed to discuss how these projects are going to be used in science teaching and the contribution of such projects to science teaching by explaining how these twenty-six projects were done.

**Key words:** Edible science projects, pre-service science teachers, science teaching

## INTRODUCTION

While students have difficulty in learning some concepts of science, teachers also have difficulty in teaching them. In order to overcome these difficulties different teaching methods are tried for attaining success. While all educators aim to achieve an easier and more permanent learning, it is generally thought that activities which draw the attention of the student on one side and which the students are entertained with on the other side enable effective learning. It is emphasized in the constructive approach, which is the common education understanding today, that the students should actively be responsible for their own learning and actively participate in the class and the learning activities. In this regard, project-based teaching is one of the effective teaching methods. Project-based teaching method stands out as a teaching method which the students can use by bringing their previous knowledge together with the new knowledge and produce solutions to certain problems in this way. In the studies related to project-based teaching methods mostly results about the effectiveness of the method are reported.

In Yılmaz's study (2015) where he has researched about the influence of project-based teaching approach on the academic success of the students and their skills of scientific process in respect to the "Electricity in our Life " unit of the 6$^{th}$ Grade Science course, it was revealed that the project-based learning is effective in increasing the academic success of the students and their skills of scientific process.

According to the outcomes of the study by Han, Capraro and Capraro (2015), there is a significant increase in the academic successes of the students in the low-success rank group among the high school students who learn through project-based learning applications based on the STEM approach. As a result of another innovative experimental study where project-based learning and STEM approach are used together, it has been reported that

there has been a positive change in the attitudes of the students following the 5 weeks-long implementations (Tseng, Chang, Lou and Chen, 2013).

Moreover, it has been indicated that project-based learning eases the learning of the subject, encourages the students for researching, and contributes to building the cause and effect relation between the learned subjects and daily life problems, to making researches, to forming their knowledge on their own and in short to a more effective and meaningful learning (Erdoğan, 2012). Similarly, according to the results of an experimental study where the effectiveness of the project-based learning method on the subject of genetics is examined, project-based learning method has a positive effect on success, attitude and permanent learning in Science course (Keser, 2008).

On the other hand, according to the results of various studies where the effect of project-based learning method on environmental education, project-based learning method has a positive impact on students' learning, expressing, and attaining general knowledge of the concepts related to the environment (Morgil, Yılmaz and Cingör, 2002; Yavuz, 2006; Erdoğan, 2007).

Hung, Hwang and Huang (2012) indicate in their experimental study of determining the impact of project-based digital storytelling that the success of the students, their motivations for learning and their problem-solving skills have increased. They also point out that project-based learning could be effective in increasing the interactions among the students and giving them more opportunities of learning (David, 2008).

Moreover, 2013 Science Course Teaching Program carries the vision of "bringing up all students as science literate individuals". For this reason, the people to be educated in the program are expected to be individuals who determine the problems, seek for and questions the solution ways, take right decisions for the solutions that they have found and have self-confidence on themselves as they solve the problems. All these require to own knowledge, skills, positive attitude, perception and values about science. Many methods are used to obtain this goal. One of these methods is to produce and present projects about science. While the project is being implemented scientific method is used and the student drives conclusions as to how to solve a problem. However, it is not often preferred by the teachers because of the problems in the material supply and for being long-term studies. When the body of literature is examined, it is observed that there are various problems about project producing and that the teachers avoid using this method due to these problems. According to Çelik (2003) the problems related to project producing are the teacher, the program, student-centred administration and supervision problems and physical condition problems (Pektaş, Çelik and Köse, 2009). In this project, it is attempted to introduce the projects related to the scientific concepts produced from edible ingredients as a project which the students and the teacher will want to eagerly implement and doesn't require significant budget and time for finding the material and implementing the project. In this regard, edible science projects produced with the project-based learning method are examined in this study.

## METHOD

Concretisation using project processes from edible ingredients is targeted in this study. For this target, edible project samples are implemented on Science Education students from a government university in Teaching Technologies and Material Design class and these projects have been displayed.

ADDIE model from teaching design models has been used in the implementation of this study. ADDIE design model which is one of the anonymous models consists of analysis, development, application and assessment stages (Şimşek, 2009). Assessment possibility which is available in each of the stages in ADDIE model makes room for correction and fulfilment of mistakes and insufficiencies noticed in the process.

### *Sample*

The study group is consisted of 4 male and 26 female senior students studying in the department of Science Education at a government university in Istanbul. These students have studied in pair groups. A total of 15 project groups has been formed.

### *Study Process*

The study has been implemented in 2015-2016 fall term. Teaching Method and Material Design is a course taught in the last grade of Science Education department. This course taught by researchers consists of three stages. The course is taught under the titles of preparing and using classical course material in teaching, using technology in teaching and developing projects in teaching. For the third stage of the course the students are given a theoretical lesson about producing science project on scientific concepts and project-based teaching during two hours-lesson

in the beginning of the term. In this study, teacher candidates have prepared science projects related to basic science topics by using completely edible ingredients. The aim in these projects has been determined as concretisation of especially the scientific concepts with which the students have difficulty in comprehending with the use of project processes within the teaching methods and material design class. In the analysis stage of ADDIE Model, the teacher candidates primarily searched about on which topics they can prepare a model/project from the topics that the primary school students have difficulty in comprehending and what they would need for preparing this model/project. In the design stage, they have prepared their projects by using completely edible ingredients. In the development stage, teaching faculty members have given feedback to the students about the insufficient and wrong parts of their projects following the pre-assessment and the projects are made to be more complete in their final forms. In the application stage, the projects have been displayed in the faculty and the opinions of teacher candidates and faculty members from both the science education department and other departments have been asked. In the assessment stage these opinions have been examined and final improvements on the projects have been planned. In the study the introduction and dissemination of these exhibited projects are targeted. Table 1 shows the project-producing process and timing.

**Table 1.** Project producing process and timing

| Time | Work |
|---|---|
| 1st and 2nd Weeks | Theoretical presentation of project-based teaching and project producing steps |
| 3rd Week | A sample project presentation |
| 4th Week | Determination and submission of project suggestions |
| 5th Week | Assessment and Admission of project suggestions |
| 6th, 7th and 8th Weeks | Researches about the project and studies on its production |
| 9th Week | Experiment of the production of the projects and their display (pilot work) |
| 10th Week | Presentation and Exhibition of the projects |

Each group has prepared different numbers of projects according to the difficulty level of their projects. The following Table 2 shows the names and the fields of the selected projects.

**Table 2.** Project groups and subjects

| Group | Project Name | | Project Field |
|---|---|---|---|
| Group 1 | Plant Cell Model |  | Biology |
| | Skin Layers Model |  | |
| Group 2 | German Cake Experiencing Meiosis |  | Biology |

| | | | |
|---|---|---|---|
| Group 3 | Atom models |  | Chemistry |
| Group 4 | Solar System Pasta |  | Astronomy |
| | Eye model Cake |  | Biology |
| Group 5 | The Phases of the Moon Cookie |  | Astronomy |
| | Life Cycle of the Butterfly |  | Biology |
| | Life Cycle of the Frog |  | Biology |
| Group 6 | Lungs Model cake |  | Biology |

| | | | |
|---|---|---|---|
| | Hand and Foot Skeleton Cookie |  | Biology |
| Group 7 | Edible RNA |  | Biology |
| | Edible Atom Model |  | Biology |
| Group 8 | Plant Cell Cake |  | Biology |
| | Cup Cake Scientific Concepts |  | Science |
| Group 9 | Candy DNA |  | Biology |
| | Brain Cake |  | Biology |
| Group 10 | Periodical Table Cake |  | Chemistry |

| | | | |
|---|---|---|---|
| Group 11 | Muffin Mitosis |  | Biology |
| | Animal Cell Cake |  | Biology |
| Group 12 | Chocolate Planets |  | Astronomy |
| | Animal Cell pizza |  | Biology |
| Group 13 | Plant Cell pizza |  | Biology |
| Group 14 | Animal Cell Cake |  | Biology |
| | Earth Crust Layers |  | Geology |
| Group 15 | Periodical Table Cookies |  | Chemistry |

Three of the projects are explained in detail below and their purposes are given.

**Example 1**

**Project Field:** Science (Chemistry)
**Project Name:** Periodical Table
**Problem:** How to prepare a periodical table model which would arouse interest and curiosity in middle-school students?
**Hypotheses:** Periodical table model which would arouse interest and curiosity in middle-school students can be prepared as edible cookies.
**Purpose:** Modelling the periodical table by using edible ingredients.

**Preparing the Periodical Table Cookie**

**Ingredients:** 1 pack of margarine, 2 tea glasses of olive oil, 2 packs of vanilla, 1/2 pack of cooking powder, 2 water glasses of starch, 2 tea glasses of powdered sugar, cinnamon, flour, sugar paste, decoration.
**Preparation:** The ingredients are added in order and a soft dough is made out of them. The margarine is used in the room temperature without being melted. The flour should be added until a soft and not sticky dough is obtained. As the dough, can easily disintegrate, the dough is spread in square forms instead of using moulds. The cookies are put in the oven tray covered with baking paper and they are baked for 25 minutes in the oven set to 180 degrees beforehand. The cookies are removed from the oven when white before turning red. The cookies are coloured by using different colour sugar paste for each group in the periodical table. The sugar paste is spread and cut in the cookie size and put on the cookies. The decorations are left in the warm water for some time. The symbol, name and mass and atom numbers of the elements in the periodical table are written on the cookies and put in row as in the periodical table on a table.

**Tips:** The butter should be in room temperature while the cookie is being prepared. The cookie can be flavoured with cinnamon etc. The cookies should not be baked more than needed. For sticking the sugar paste on the cookie, honey, water or jam can be used.


**Example 2**

**Project Field:** Science (Biology)
**Project Name:** Plant Cell Model
**Problem:** How to prepare plant cell organelles from edible ingredients which would arouse interest and curiosity in middle-school students?
**Hypotheses:** Plant cell and organelles which would arouse interest and curiosity in middle-school students can be prepared from cake and fruits as edible ingredients.
**Purpose:** Preparing edible Plant Cell and organelles.

**Preparing the Plant Cell as a Cake**

**Ingredients:** 2 packs of pudding, 1 kiwi, 2 litres of milk, 1 potato, 1 pack of whipped cream, chocolate pieces, 3 packs of petite-beurre biscuit, bonbon, 1 orange, 1 apple, 1 banana, rectangular glass pot.
**Preparation:** Firstly 2 packs of pudding and 1 litre of milk are put in a middle-sized pot and are boiled. After the pudding is ready, the biscuits are lined in the glass pot and pudding is poured on the biscuits. The same process is applied for the desired number of layers. Pre-prepared whipped cream in the fridge is poured on the cake and spread. The organelles are formed using the remaining ingredients. The chloroplast is made of kiwi, the cell is

made of orange, the endoplasmic reticulum is made of orange peel, cell wall and membrane are made of bonbon candies, golgi apparatus is made of apple, mitochondria is made of potato, peroxisome is made of mandarin, ribosomes are made of chickpeas and vacuole is made of banana.

**Tips:** If you prepare the cake and keep it in the fridge one day before serving, the pudding and the whipped cream will have a more beautiful appearance. For the fruits, not to get dry and change their colour, their contact with air should be eliminated. Stretch film can be used for this purpose. The bonibon and fruits on the cake should be placed as late as possible before serving the cake. For not to confuse which fruit represents which organelle their names can be written on them with the help of a toothpick.

**Example 3**

**Project Field:** Science (Astronomy)
**Project Name:** Solar System
**Problem:** How to prepare solar system from edible ingredients which would arouse interest and curiosity in middle-school students?
**Hypotheses:** Solar system which would arouse interest and curiosity in middle-school students can be prepared from pasta as edible ingredient.
**Purpose:** Preparing an edible solar system.

**Preparing Solar System with Pasta**

**Ingredients:** Boiled pasta, cucumber pickles, peas, carrot and potato garniture, boiled corns. Boiled potato, carrot, radish, boiled beet, green pepper, red pepper, yoghurt.
**Preparation:** Firstly, the pasta is boiled. Garniture, corns and pickles are mixed and put in medium-deep pot. The prepared mix is poured on the boiled pasta and mixed together. Finally, the yoghurt is added and all ingredients are mixed together. They are placed inside a deep and rectangular pot in an orderly way and the upper layer of the solar system is made with the remaining ingredients. The sun is made of a big slice of boiled potato, the earth is made of green pepper, Mars is made of red pepper, Venus is made of potato garniture, Saturn is made of white radish, Uranus is made of red radish, Jupiter is made of corns, Neptune is made of beet and Pluton is made of a single pea.


## CONCLUSION

In this study, it has been targeted to show the teaching of scientific concepts with the use of science projects from easily found, cheap and edible ingredients by using project-based teaching processes compatible with the scientific process stages. For this purpose, education faculty senior students have been separated to pair groups and each group has prepared science projects using edible ingredients such as candy, cake, chocolate and pasta about a science subject that they have chosen and they have exhibited these projects. As a result of the study it can be said

that the projects related to scientific concepts from edible ingredients have been successfully developed and that the students could complete the projects successfully in accordance with their purposes. The fact that this kind of projects can be prepared from edible ingredients which can be accessed easily and in a cheap way can be thought as a different project method. The students have chosen their project topics on their own and prepared their projects using different methods in consideration of their possibilities and situations. It has been observed that the female students generally prepared the ingredients on their own and the male students mostly preferred to use ready ingredients or had the material done by others. It can be asserted that such kind of projects challenges the imagination of the students and improves their creativity. It is observed that the motivations of the students increase with this kind of projects with reactions regarding their presentation of the projects and the following eating activity despite the small problems experienced during the preparation. One of the most striking results about edible projects is that the students not only use the scientific processes and challenges their creativity but also enjoy the project processes while trying to prepare edible projects as a solution to a problem. The presentation of projects and the following tasting of the projects and the comparisons made between the projects have added entertainment and excitement to the study. In conclusion, it can be said that the students have used scientific process skills, their scientific creativity has improved, their interest, curiosity and motivations have increased and especially that they have enjoyed while preparing the edible science projects. It has been observed that tasting the models that they have prepared following the presentation of the projects and sharing these with the other students have resulted in attracting more attention as compared to other projects. The study by Keser (2008) also suggests that project-based teaching applications have positive impact on success, attitude and permanent learning in Science education. It has been observed that the awareness of scientific concepts in students have increased during the preparation and exhibition of the projects. The study by Acaray (2014) also suggests that the project-based teaching applications have increased the awareness of students about the subject. Some teacher candidates have indicated that they noticed that they had misunderstandings and lack of understanding about the project subject and they have corrected these in this process. According to the results of the experimental study by Yılmaz (2015), project-based teaching applications have positively influenced the academic success of the students according to the control group. Also, there are many studies supporting this conclusion (Morgil, Yılmaz and Cingör, 2002; Yavuz, 2006; Erdoğan, 2007; Cam, 2013, Han, Capraro and Capraro, 2015).

This study is expected to contribute to the related literature and to be one of the first studies analysing the edible science projects as an innovative approach with the potential of being used as a teaching material as well as being one of the projects which the primary school students can prepare within the science class. The introduction and dissemination of these projects which are implemented for the increase of such kind of projects and their use in all grades of education are quite important.

## SUGGESTIONS

It is thought that the dissemination of this kind of projects in all stages of education could revive and add entertainment to activities such as science festivals in the middle-schools and that they could increase interest, curiosity and motivation of the students. The implementation of this kind of projects in middle-schools is also possible. However, as it is a cooking activity it can be planned in a way that the parents also participate. It can also be said that there could be more opportunity for the school, the family and the students to socialise in this way.

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# VOCATIONAL ACQUSITION OF STEM TEACHERS IN CERN WORKSHOPS

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**ABSTRACT:** Louis De Broglie suggested the building of atomic physics laboratory in European Culture Conference that was held on 9th December 1949 in order to provide the previous achievement and dynamism to Europe in the fundamental sciences after the World War II. Isidor Rabi also suggested the building of a regional laboratory in 5th UNESCO Conference which was held in Florence, 1950 in order to develop the international scientific cooperation. Eleven countries decided to establish a European Council for Nuclear Research in Paris, 1951. Establishing treaty was signed by 12 countries in 1953. Approvals from the parliaments of Denmark, France, West Germany, Greece, Italy, Netherlands, Norway, Sweden, Switzerland, UK and Yugoslavia were completed on 29th September 1954, and CERN European Organization for Nuclear Research" was established (CERN, 2016). Today, CERN, having 21 members and 4.000 researchers, is the largest accelerator and research laboratory of the world, and is the center of excellence that provides opportunity to develop numerous technological products as well as many scientific discoveries. Innovations, which facilitate our lives from health to communication, energy to material science, security to food sector in every field, emerge through technological devices and systems such as particle accelerators and detectors that are developed by and used in CERN. There are full-scale experiments which are maintained, renovated or at the construction phase today as always being, or designed for future in CERN that is the biggest international scientific and technologic corporation organization of the world (Ankara University, 2016a). The science of physics goes far beyond Newton and Einstein and the particle physics is the future's scientific field. In particular, the inventions, used in the diagnosis-purposed devices in medicine, indicate a new future. For this reason, our teachers should always upgrade their knowledge and should be ready for educating the 21st Century's students. Turkey officially participated in CERN in 2014, and right after, the teacher Workshops were organized. Totally 229 teachers participated to six workshops that have been held in CERN where 150 Turks at PhD, post-doctorate degrees and executing the research from Turkish and foreign universities worked until today. In this article, the professional knowledge and experience acquisitions of teachers who attended the workshops in CERN laboratories on the base of innovation, entrepreneurship and technology in education, dissemination of knowledge by the teachers to other schools, colleagues, policy-makers and students when they come back to school. The article finalizes what should be done in this field for advance development.

**Key words:** CERN, multidisciplinary training, in-service training, STEM

## SCIENTIFIC RESEARCHES IN CERN LABORATORY

The basic function of CERN is to examine the building blocks of substance and their interactions with each other, to execute the experimental works on this matter, to educate the future's scientists, engineers and qualified workforces, and to develop the technologies necessary in researches. The subject of particle physics is the building blocks of substance and interactions between them. It is necessary to collide the substance with higher energies in order to study the structure of material at very small dimensions. Higher the collision energy, possible to study at smaller dimensions. There are accelerators which the experiments at their own energy limits are executed as well as the particle accelerators allowing for reaching to the highest energies upon completing each other in CERN. CERN becomes a center of attraction for scientists all over the world and associates the people from different countries and cultures. As two countries host for main premises of CERN which is located at Switzerland-France border, then the second campus, which was established later, is located within the France borders. CERN appears as a middle-sized town with the social facilities that are used by more than 4.000 staff and thousands of researchers from other organizations every day. Significant part of CERN employees are the young researchers who execute the PhD studies, and work in informatics area in the industry. Due to dense settlement in the region, the large accelerators in CERN were installed within the tunnels under the ground, and only the zones, where the support buildings that must be on the ground are available within the experiment regions, are added to the CERN premises. For instance, very small part of Large Hadron Collider in 26 km length is available within the CERN premises. The main reason why the tunnels are approximately 100m bottom of ground is to avoid preventing of main flow ways of underground waters and to have the accelerator sit on the sound rock base. The top institution of European Organization for Nuclear Research is a council, formed by the participation of two persons, one representing the political governance and other representing the science from the member countries. Despite of each country is represented by two persons in the council, each country has one voting right. The attention is paid to take the decision by common consent. The Science Board, which acts as the consultant for scientific programs to the

Council, consists of the scientists whom their scientific qualifications are recognized worldwide (Akgun et al., 2014).

**Particle Physics**

Particle physics is the science of "smallest" which studies the infrastructure of substance and its interactions. The smallest ones, subatomic particles create our world together with living beings, other planets, starts, namely everything in our universe upon coming together. Different dimensions are studied by the different scientific branches. We make our observations with our eyes in mechanical field at the meter level. As the dimension increases, first, we observe other planets in our solar system, other star systems, other galaxies and far fields of universe. We call the branches which are interested in such dimensions as astronomy, astrophysics and cosmology, respectively. Cosmology explains $10^{21}$-$10^{22}$ meter levels and uses advanced telescopes and satellites. We see the cell, DNA, electron cloud and atomic nucleus, respectively at the micro level. It is possible to examine the section up to electron with microscopes. The scientific branches, which study the section up to nucleus, are chemistry, biology, solid state physics and nuclear physics, respectively. Atom nucleus is formed by the positively charged protons and uncharged neutrons. The protons and neutrons are formed by the particles, called quark. The scientific branch using the particle accelerators and detectors is called particle physics in order to make observation at this level.

**Accelerator Physics**

It is necessary to collide the substance at higher energies in order to examine the structure of material at very small dimensions. Higher the collision energy, possible to study at smaller dimensions. The particle accelerators are used for this. Working principle of electrostatic accelerators is based on the passing of charged particles from a fixed potential difference and accelerating them. The simplest electrostatic accelerator is a pair of parallel plate which is connected to two poles of a direct current generator. When the voltage is applied between two plates, the electric field occurs between the plates. The charged particles may be accelerated in this electric field. After discovery of atom nucleus in 1911, Ernest Rutherford thought that the atom nucleus might be split with the accelerated particles. John D. Cockroft and Ernest T. S. Walton, the students of Rutherford, designed a 800kV generator in order to be used in accelerating the proton in 1928. They accelerated the protons up to 400keV energy with the electrostatic accelerator which they produced and hit them to a lithium plate. The accelerated protons split the nucleus of lithium atom and created two helium atom nuclei ($Li^7+p \xrightarrow{yields} {}^4He+{}^4He$). This the first experiment which an atom nucleus is split artificially. American physicist Robert J. Van de Graaff reached to 20MV in 1931. Based on the idea of Swedish physicist Gustaf Ising on using the alternative current in accelerators, Norwegian physicist Rolf Wideroe accelerated the positive ions up to 50keV using 25kV power supply with a linear accelerator that he produced in 1928. In 1947, American physicist Luis Alvarez developed a system which might accelerate the particles at higher frequencies and produced the system, called Drift Tube Linac (DTL). As understood from their names, the circular accelerators, which have the circular shapes and are commonly used today, are cyclotron and synchrotron. The first successful cyclotron was developed by Ernest Lawrence and his student, M. Stanley Livingston in 1931. This cyclotron accelerated the protons up to 80keV using 1.8kV RF generator. The synchrotron enables the particles moving in a circular orbit through the magnetic field. The particles move in a metal tube, called beam tube. The largest and most powerful synchrotron and accelerator today is the Large Hadron Collider in CERN (Akgun et al., 2014).

**Detector Physics**

In this context, "seeing" the subatomic particles also mean, in fact, to see their traces. Energy (E), momentum (p), charge (q), spin (s) and similar characteristics are measured and recorded in the detectors which is briefly described below.

**Cloud Chamber**

This detector, which was invented by Wilson in 1911, caused the inventor won the Nobel Prize in 1927. Especially, it was used in the experiments and observations which were made during 1920-1950. Essentially, it is a closed media that includes the excessively saturated alcohol vapor. The charged particles, entering from chamber, release the energy throughout the way that they follow and intensify the alcohol vapor and leave the traces like cloud. The photographs of occurred traces are taken and recorded in order to be examined later. If a magnetic field is applied perpendicular to the entrance direction of particle beam to the chamber, then occurring Lorentz power causes the change of particle direction. Thanks to this, the charge and momentum of particles, which leave the spring-shaped

traces, may be measured. Thanks to this detector, the positron was discovered in 1932, and muon in 1936, and kaon in 1947.

**Foam Chamber**

This detector, which was discovered by Glaser by early 1950s and was awarded the Nobel Prize in 1960, is a liquid filled cylinder or sphere. The liquid is maintained just below the boiling temperature under the certain pressure; for example, it may turn to liquid hydrogen at 27 K temperature and under 5 atmospheres of pressure. When the particle beam, which the trace will be examined, reaches to the chamber, the pressure is dropped immediately and the liquid is heated. The charged particles in the particle beam lose their energy via ionization. This vaporizes the instable liquid and creates the bubble nuclei. The photographs are taken within 1 or 2 microseconds. More than one camera may take the photograph from different angles and may reduce the position resolution by 10 microns. It may be built larger than cloud chamber and since it includes denser liquid, it may detect the particles with higher energy. The weak uncharged currents were found with BEBC and Gargamelle detectors which run with this principle in CERN.

**Accelerator Experiments**

ATLAS experiment (A Toroidal LHC ApparatuS), which Turkey also participated in, is one of six experiments that were started to perform in CERN on 10$^{th}$ September 2008 and were performed in LHC accelerator. ATLAS and CMS are general purpose, LHCb is about b-physics, LHCf experiment on astroparticles (cosmic beam) physics, Alice on heavy ion physics and Totem on measurement of total effect section.

When the proton beams are collided in the experiment, many fundamental particles occur at the different energies. ATLAS experiment is designed general purpose so that it will measure the traces, energies and momentums of many particles which have been observed or not until today. The collision energy of LHC, 14 TeV and radius, $10^{34}$ p/cm²/s are the characteristics which were not obtained in the previous experiments. These difficult circumstances make ATLAS experiment the largest and most complex experiment among the particle physic experiments that have been performed until today. ATLAS experiment passes into history as one of two LHC experiments which Higgs Boson was observed along with CMS on July 2012. The researchers are currently carried out in order to collect the meaningful data about super symmetric particles (CERN, 2016).

**Neutrino and Higgs Boson**

There are three radioactive radiation; alpha, beta and gamma. As the instable nuclei release their excessive charges on them and turn to the stable status, they disintegrate. Alpha disintegration occurs, when any radioactive instable nucleus releases the alpha particle (in fact, helium nucleus with higher energy) and turns to a stable nucleus. In this conversion, there are two units of reduction in atomic number and four units in the mass number. The example is turning of radium to polonium: $Ra^{222} \rightarrow Po^{218} + \alpha$. In gamma disintegration, if $\gamma$, then some radioactive nuclei don't release all energies during alpha and beta disintegrations and maintain their higher energy status. They release the gamma radiation in order to turn to the stable status. In this case, there is not any change in the atomic number and mass number of the atom. Beta disintegration means the case where the instable nuclei turn to the stable status through releasing beta particle, namely electron. During this conversion, no change occurs in the atomic number of atom, but there will be 1 unit of reduction in the mass number. By early 1900's, the example for known disintegration was turning of carbon nucleus to nitrogen: $C^{14} \rightarrow N^{14} + \beta$.

Neutrino was first discovered by Wolfgang Pauli in 1930; it occurred in the nucleus and as a result, was prescribed to meet the law of conservation of mass, law of conservation of momentum and law of conservation of angular momentum in beta disintegration where 1 electron, 1 proton and 1 anti-neutrino were released ($n^0=p^+ + e^- + \sim\nu_e$). Pauli stated theoretically that an undetected particle bears the energy, momentum and angular momentum differences between the inputs and outputs, and called this estimated particle as *neutron*. However, after James Chadwick discovered a particle which its mass was larger in 1932 and when he also called it as neutron, Enrico Fermi, who produced the theory on beta disintegration, eliminated this confusion by calling this particle which its mass was smaller as *neutrino* that means *smaller neutron* in Italian. Neutrino is one of the fundamental particles which has almost light speed, electrical charge is zero and passes throughout the materials almost without interaction. These characteristics make the detection of neutrinos quite difficult to be detected. Neutrinos, which are denoted with $\nu$ (nu) letter in Greek alphabet, have very small masses, but not zero. Neutrinos resemble the electrons, except not having the electrical charge. Since the neutrinos are non-charged electrically, they are affected by the electromagnetic forces. Neutrinos are only affected by the 'weak' force which its distance is very smaller than electromagnetic force; for this reason, they may pass through the materials almost without interaction. Since

the neutrinos have the mass, they interact with gravitation same as other particles with mass; however, the gravitation is the weakest one among known four forces. Neutrinos occur in the certain atom disintegrations or in the sun, nuclear reactors or as a result of nuclear reactions, when the cosmic beams collide with the atoms. There are three types of neutrino: electron neutrino, muon neutrino and tau neutrino. Each type of neutrino has one particle, called anti-neutrino. Electron neutrino (or anti-electron neutrino) occurs, when proton turns to neutron or vice-verse – two forms of beta disintegration. Interactions, including the neutrino, are the systems created by the weak force. Most of neutrinos released by sun reach to the Earth. Approximately 65 billion neutrinos reach to $cm^2$ of Earth perpendicular to sun per second (ATLAS Group, 2012).

The mass, which Newton defined as amount of matter and is the resistance of material to the acceleration, is an attribution which determines the amount of gravitation between it and other materials. According to Einstein, the mass gives the energy amount which corresponds to the stable material. The mass of proton is 938, 3 MeV. Total mass of u + u + d quarks that form proton is 9, 4 MeV and is a small part of proton mass. Remaining 928, 9 MeV of mass is the kinetic energy of quarks and gluons in the proton. The attribute of these quarks is mass, namely the mass which fundamental particles gain through Higgs operation. According to Higgs theory, there is a Higgs field at every single point of universe. Field is a fact which has a value at every point of space-time. This field may be assumed as a magnetic field that allows the magnets pull or push each other, or forms the iron dust around the magnet. The fundamental particles gain the mass interacting with this Higgs area. Neutrinos, which area created in the Large Hadron collider and disintegrate within microsecond, create the Higgs field which enables the material gain the mass.

## PARTICIPATION OF TURKEY IN CERN

Turkey's relation with CERN has been coordinated by TUBİTAK during 1961- 2015, and from 2006, it was assumed by Turkish Atomic Energy Authority (TAEK, 2016). The cooperation agreement was signed between TAEK and CERN on 14th April 2008, and the preparations of official application by Turkey for CERN membership were accelerated and the application was filed on 18th May 2009. The application and works of Turkey related to CERN membership were discussed during the CERN Council meeting, held on 17th December 2010 and were considered positive. The application by Turkey related to member associate was filed via Government letter, dated 17th October 2012 to CERN and this application was accepted in the CERN Council meeting, dated 13th December 2012. After the mutual negotiations and evaluations between Turkey and CERN, CERN Council accepted Turkey's application related to member associate with its decree, dated 20th March 2014. The agreement on membership associate between Turkey and CERN was signed by CERN director, Prof. Dr. Rolf HEUER and Turkey's UN Geneva Permanent Delegate, Ambassador Mehmet Ferden ÇARIKÇI and the Minister of Energy, Taner YILDIZ on 12th May 2014. The agreement was approved by common consent in the General Board of Turkish Grand National Assembly, dated 22nd January 2015 which TAEK was also represented.

The primary provisions of this agreement, which was signed in a period when works and investments related to common and effective using of particle accelerator and detector technologies (Turkish Accelerator Center, etc.) also increased in our country, are given below in summary: Turkey accepts the legal infrastructure, operation rules, regulations of CERN and the decisions which are taken by its organs through agreement. Turkey shall affect minimum one tenth (1/10) of the full membership contribution (membership fee) which is calculated according to the economic size and population, provided that it shall not be less than 1 Million CHF. Turkey, which participates in education and training programs of CERN as well as in scientific research programs, has the right to be represented in CERN Council (except the closed sessions) without voting right and may begin to speak and give representation without expecting any invitation. Turkey has the right to be represented in the meetings of CERN Finance Commission. Scientific representative of Turkey in Council may attend the CERN's Science Policies Meetings as an observer. The citizens of Republic of Turkey may apply for CERN personnel assignments to the academic memberships, studentship and faculty memberships through the limited and periodical contracts. Firms, which offer the Turkish origin goods and services, may submit the bid to the CERN contracts based on the Regulation on Implementation of CERN Financial Rules. Turkey may assign an industry contact officer in CERN. The compound financial amount of works to be carried out by Turkish firms in CERN shall not exceed the financial contribution to be made by Turkey to CERN within the scope of agreement in no case. Turkey may turn from common membership associate status that is gained through this agreement into the membership associate status as a pre-phase of full membership and then, full membership status in CERN.

### Keep Calm and Focus on CERN Projects

There has been an intense interest and curiosity about the CERN laboratory, its accelerator and particle physics due to the discovery of the Higgs particle. This interest is not misplaced, because particle physics and accelerator

technology are very active and colorful disciplines, which live on constant innovation and which push the limits of science and technology. It is very important and useful for students, teenagers and everyone who carries the excitement of discovery inside them to get to know to this field aimed at finding the most basic building blocks of the Universe (CERN Project, 2016). So, Keep Calm Project is developed with the following expected results;

- Learning of the basic concepts of particle physics and elimination of misconceptions
- Learning of the ways of scientific knowledge
- Achievement of a positive attitude towards science
- Gain of some minimal experience with using basic software in this field
- Creation of a web site and virtual classrooms
- An increased capability to provide scientific explanations for natural phenomena
- Increased knowledge of applications on basic sciences (math., physics, chemistry)
- Better comprehension of the scientific method and research skills
- Increase in students' verbal and written communication skills
- Capability of directly associating gained knowledge with technology and industry;
- An enhanced vision for application areas
- Development of insight based on basic concepts rather than details
- Learning how to describe an experimental study

The project tools which may be used by the trainees are the followings (Akgun et. al., 2014);

- To create an atom model by using http://sourceforge.net/projects/jmol/ Periodic table application
- Physical activities simulator by STEP
- For supporting the CERN experiments from GRID computing system
- http://boinc.berkeley.edu/
- To prepare online questions by kahoot.it
- To create websites: https://tr.wordpress.org/
- Sharing of studies and research papers with Twin space
- Information meetings with e-twinning portal and e-conference system of science trip
- How to adding activity photos to the Prezi presentation tool
- e-conferences: e-twinning portal and e-conference system of science trip
- How to use Voki, Padlet, Canva or Postermywall, Littlebird Tales, eTwinning Live,
- Modelling with sketch up, weebly /edmodoo, Kahoot.it

**BeaLine Project Contests**

The incoming proton beam from the PS accelerator impinges on the North target and thus produces the particles for the T9 beam line. The collisions of the protons with the target can provide a variety of particles, such as electrons, positrons, muons, pions, kaons and (anti-)protons. The T9 beam line may be used on different projects. The participation should be provided in "BeamLine" Project contests held in CERN with talented and enthusiastic students (Beamline, 2016). The student projects, which were participated in this contest previously and were awarded the prize, may be delivered to Turkish and foreign teachers whom it may be communicated with in order to prepare a new project (Beamline, 2016). It is possible to access to the experiment fields and use the possibilities through internet (CERN, 2013).

## CONTENT OF CERN TEACHER WORKSHOPS

The professors and subjects of workshops organized by Turkish Scientists in CERN is given below. The content of five-day workshops is as follows;

- About CERN and expectations, Prof. Dr. Samim Erhan, University of California Los Angeles
- Particle Physics, Prof. Dr. Bora Akgün, Rice University
- Detector Physics, Prof. Dr. Saime Gürbüz, Boğaziçi University
- Astroparticle Physics, Prof. Dr. Cenk Yıldız, University of California Irvine
- Accelerator Physics, Prof. Dr. Veliko Atanasov Dimov, Boğaziçi University
- Neutrino Physics, Dr. Umut Köse, Padova University, INFN
- About Higgs, Prof. Dr. Sezen Sekmen, CERN
- BL4S 25', Prof. Dr. Saime Gürbüz, Boğaziçi University
- Show with Computer, Prof. Dr. Gokhan Unel, University of California Irvine
- Detector Workshop @UBS (2Cloud chamber & electron tube)

- Detector Workshop group "muon" and "antimuon", Prof. Dr. Saime Gürbüz, Boğaziçi University
- AD and Data Center, SM18 and CAST, ATLAS and SC, AMS & CCC tours

## CRITERIA FOR SELECTING CERN WORKSHOP TEACHERS

The teachers, who will attend the workshop, are evaluated and determined by Turkish scientists in CERN, MEB official and the teachers who attended the CERN workshops previously through a form which they will complete according to the below criteria**.** The number of applicant teacher increases gradually upon more recognizing and knowing the CERN Workshops**.** 36 teachers were selected among 750 teachers who applied for Sixth Workshop.

- Those who have the higher learning, researching and knowledge sharing desires,
- Those who are able to show that they really follow the scientific developments in particle physics with the contents of their questions,
- Those who are experienced, effective in education life, attend the training, and direct their students toward the contests,
- Those who are at the beginning of their work lives and may evaluate the investment for a long-time
- Those who declare that they give seminar to the public by travelling to surrounding provinces and counties, not only to the students,
- Those who may collect the sufficient experience during their work lives and may affect and direct their young colleagues,
- Those who may address toward large masses through electronic or similar medias,
- Those who may inform the students and society rather than providing their personal academic development with what they learn in CERN,

## PROFESSIONAL GAINS OF TEACHERS THROUGH CERN WORKSHOPS

As total 6513 teachers from member and candidate countries attended the CERN Workshops during 1998-2013, only 3 teachers from Turkey attended such Workshops. From 2014, the distribution of 229 teachers, who attended the CERN Workshops with the significant initiatives from Turkish Team of CERN according to the provinces, is given in Figure 1.


**Figure 1:** Distribution of 229 Teachers attended the CERN Workshops according to the provinces (Teacher Training Programs, 2016)

The survey was carried out in our teachers who attended the CERN Workshops (Workshop Teacher Survey 2016). Primary gains of the teachers may be summarized as follows;

- Teachers obtained the significant scientific gains and encouragements related to their profession by visiting CERN which was the most important laboratory of world.
- Their views about education, research, profession and world changed significantly.
- Peer learning started. It is provided the accession of them to many scientific communities in the country and abroad.
- Our teachers, who attended the workshop (CERN Workshop, 2016), shared their knowledge and experiences giving many conferences and making presentations upon returning, notably in their schools and provinces.

- For the first time, they went abroad for education through Ministry of National Education official and financial support which highly motivated them.
- They met their colleagues in their schools and abroad and obtained information about their works.
- They observed the implementation of theoretical knowledge practically and implementation of research results to the industry.
- They remembered to update their knowledge and need of making research,
- It opened a road to similar laboratory visits and Workshops for our teachers in the Ministry.
- They gained moral and encouragement understanding that the Ministry valued them.
- They knew many websites and portals, and began to establish the similar websites and portals.
- They knew to contribute to spreading of knowledge giving conferences in their schools and other schools when coming back, and network establishing process started in the country.
- They gained the ability of using e-conference system, and enhanced their presentation skill.
- The awareness increased about the subject today when the accelerator technologies developed and the works on establishing the centers were currently carried out in Turkey.

## CONCLUSION AND RECOMMENDATIONS

The following conclusions and recommendations are developed analyzing the poles that are made to 138 teachers who attend the Workshops, face-to-face interviews with them and observations of CERN researchers at the end of Workshops which have been repeated six times until today;

- As seen from the above developments, the science of physics develops based on the discoveries of Newton and Einstein, but in a speed much far beyond them. If our teachers, whom the subjects which they know and tell are available as the very qualified visuals in the websites that the students may access, don't refresh their knowledge permanently with the new information and discoveries, then they will face with the fact of professional death. For this reason, CERN Workshops, which we consider them very important, must be organized in other scientific fields also.
- It is observed that the workshops and educations are very beneficial, and should be maintained. 5-day preparation should be made before attending the CERN Workshop in Turkey. The workshops at higher levels may be organized for our teachers who attended the workshop one year before. For this purpose, the cooperation may be established with TAEK and Ankara University Institute of Accelerator Technologies.
- The workshop period should be minimum 10 days and more number of experiments should be performed. CERN Scientists should organize e-conference to the CERN teachers in certain periods.
- The participation from science high schools, which their number reaches to 500, and from provinces, where no participation was obtained previously, should be encouraged and proliferation should be provided.
- MEB should support the undergraduate education of CERN teachers (Ankara University, 2016b).
- List of teachers, who will attend the workshop, should be issued not more than 3 months before the workshop date.
- The content of program, addressing to the teachers and students of high school and secondary school, should be differentiated.
- The projects should be prepared which will introduce CERN and particle physics and will direct the scientific productivity, and the science fairs should be organized within the scope of TUBİTAK4006 Program.
- The cooperation should be established with Ministry of National Education, TUBİTAK Science Centers, TUBİTAK Science and Society Department, TAEK and Ankara University Institute of Accelerator Technologies.
- http//keepcalmandfocusoncernprojects.weebly.com/project should be proliferated.
- The faculty members and teacher candidates from faculty of education in the universities should attend.
- Networking work should be carried out between teachers from other countries who attend the Workshops and our teachers.

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# ANALYZING AGENT FUNCTION DESIGN TEACHING IN ELECTRICAL ENGINEERING EDUCATION

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**ABSTRACT:** In this study, the effect of chosen examples in agent function design teaching is aimed to be analyzed. Traditional problem solving method is used at the beginning of agent function design teaching. Then, a workshop has been organized before a quiz. Totally 22 number of students have been divided into two groups. Each group members are randomly chosen. Each group needs to develop an agent function in a specific time. All the participants of the first group, those are expected to find a new example; choose the solved examples in lectures. Some of the students in the other group perfectly develop an agent function for a given new example. Results of the study revealed that students who asked to develop a new example require additional thinking than the ones that have an example. Both groups have been asked the same questions in midterm and final examinations. Student's success on agent function design is also analyzed.

**Key words:** teaching methods, agent function, robot design, robot control

## INTRODUCTION

In higher education, especially in engineering faculties, students are aimed to be reached to the critical thinking level for several courses in their education. Engineering education mainly involves critical thinking and problem solving activities. In all engineering programs, courses in last semesters, students are generally fulfilled to perform a project which requires creativity. Therefore, in the education of engineering faculties, students' learning abilities should be aimed to reach higher thinking levels.

Teaching methods are generally divided into two categories; Teacher Centered Approaches and Student Centered Approaches. Teacher Centered Approaches are widely used teaching methods. The well-known and mostly used teaching strategies can be classified into three. These are namely; expository teaching, discovery teaching and inquiry teaching strategies (Demirel, 2009). Especially, education in engineering faculties' given by an expert teacher is an example of expository teaching method. Expository teaching method can be more effective with discussion and problem solving techniques (Sönmez, 2011).

Robotics is one of the multidisciplinary course in Electrical and Electronic Engineering program in Cyprus International University. This course involves robot design for a specific task and real time robot control. This study is motivated from the students' learning difficulty about agent function design learning which is the first step in robot design topic. This topic requires higher problem analyzing ability and additionally students should have good computer programming skills. Traditional problem solving methods are used at the beginning of the agent function design teaching. After giving the definition of an agent function, a simple vacuum cleaner world problem is introduced to the class. This problem was firstly solved in the class with discussions. After that, the same problem is modified twice with small changes having an increasing complexity. Because of the students' difficulties to find an acceptable solution, a new teaching method for agent function design is applied.

Totally 32 number of students were registered to the Robotics course at the beginning of the 2015-2016 fall semester. After finishing the explanation and problem solving parts about agent functions, one workshop has been organized before a quiz. Only 22 students have attended the workshop and these students were divided into two groups. Each group members are randomly chosen. Like in workshop, in the quiz, one group has been asked to develop an agent function for a given example, whereas the other group asked to create their own example. Each group needs to develop an agent function in a specific time. All the participants of the first group, those are expected to find a new example; all they choose the solved examples in lectures. Some of the students in the other group perfectly develop an agent function for a given new example.

Benefits of problem based learning are studied by Yenal, (2003). That research reports that in adult education the problem based learning method might increase students' cognitive competence and higher thinking ability. Another study about student centered learning method is done by Başbay, (2005). The effect of project based on

learning approach which is supported by layered curriculum is studied and results of that study shows that students' learning levels are increased. Especially, students having higher level learning abilities are positively affected.

In this paper, two well-known cognitive level teaching model and approach; namely Bloom's Revised Taxonomy and Layered Curriculum by Kathie Nunley, are summarized in the Teaching Methods section. The effect of chosen examples in agent function design teaching is aimed to be analyzed with this study. The analysis of students' performance about agent function solutions and the observations based on new teaching method is given in Results and Findings section. Observations about example choice are discussed in Conclusion section.

## TEACHING METHODS

Effective teaching methods should be used to teach today's new technology to the next generations. Psychologists and educationists are working on learning taxonomies and effective teaching methodologies. Widely accepted learning taxonomy is introduced by Benjamin Bloom in 1956 and it is revised by Anderson and Krathwohl in 2001 (Krathwohl, 2002). In the last decade, a Student-Centered teaching approach namely Layered Curriculum is introduced by Kathie Nunley (2005). The reason of all these studies is to have improvement in the students' learning levels to desired learning outcomes.

If a teacher uses traditional methods in higher education, the teacher determines course objectives and tasks by her/himself. On the other hand, if the teacher prefers to use interactive teaching method such as problem based learning and cooperative learning students' interest increases. Armstrong observed that the example choice increases the students' interest about what they are taught (Armstrong, 2012).

In this study, discovery teaching strategy is applied for agent function design teaching which is one of the Teacher-Centered Approach. In order to increase student interest in agent function design learning, some of the students are asked to find their examples related with agent function design activities as a workshop and a quiz. The implementation details of this strategy are explained in Agent Function Teaching section.

### Bloom's Taxonomy

Benjamin Bloom and his friends aim to create a basis to evaluate a course or curriculum in a broad educational goal in cognitive level. Additionally, this taxonomy can be used to determine the consistency of a course objective. The original taxonomy consists of six layers starting from simple to complex categories. When it became a popular within the researchers, some discussions have been started about the lack of the original taxonomy. Especially, analysis done by many researchers put emphasis on the objectives at knowledge category requiring only recognition or recall of information. Therefore, the original teaching-learning taxonomy is revised by Anderson and Krathwohl et al (Krathwohl, 2002). The category names for both taxonomies are summarized in Table 1.

**Table 1.** Bloom's Taxonomy versus Revised Taxonomy

| **Original Taxonomy (1956)** | **Revised Taxonomy (2001)** | **Level of Thinking** |
|---|---|---|
| Evaluation | Create | Higher order thinking |
| Synthesis | Evaluate | ↑ |
| Analysis | Analyze | ↑ |
| Application | Apply | ↑ |
| Comprehension | Understand | ↑ |
| Knowledge | Remember | Lower order thinking |

The brief definitions of revised taxonomy is listed below (Krathwohl, 2002).

1. Remember: Retrieving relevant knowledge from long-term memory.
2. Understand: Determining the meaning of instructional messages.
3. Apply: Implementing a procedure in a given situation.
4. Analyze: Detecting how the parts relate each another and to an overall structure or purpose.
5. Evaluate: Making critiquing based on subject.
6. Create: Combining elements together to form a novel or an original product.

The above listed categories are aimed to assist teachers to plan their course objectives. It would be useful to prepare questions having increasing difficulties and related points.

**Layered Curriculum**

To teach a class of students having mixed-ability levels, a simple teaching approach is developed by Kathie Nunley. This method consists of three layers. Layer C is the bottom level which includes several assignment choices with basic information. The Layer B consisting of problem solving activities where students are able to show applications of the knowledge gained from Layer C. The top and the last layer is Layer A requires critical thinking and analysis about the real-world issues (Nunley, 2005).

Students decide their work layers and points are assigned with oral presentations and discussions. Depending on the worked layer, each student earns a grade of C, B or A. The Layered Curriculum design is illustrated in Figure 1.

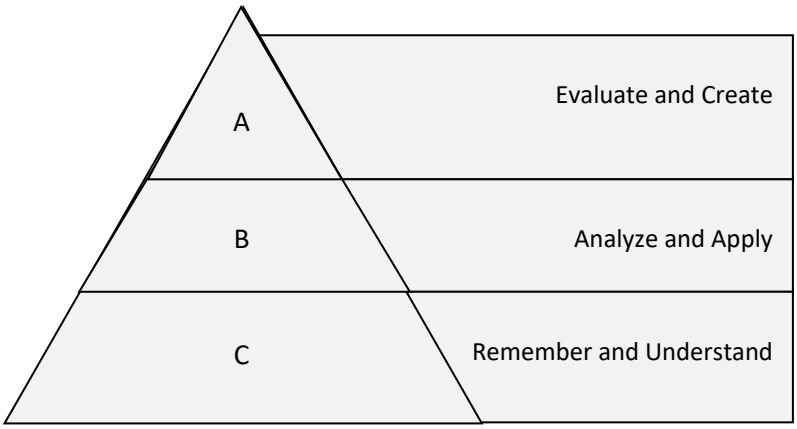


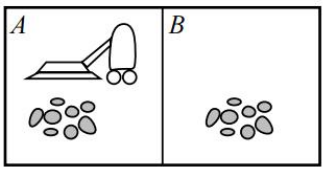

**Figure 1.** Layered curriculum

Like Bloom's taxonomy, the Layered Curriculum teaching approach also categorizes the learning levels. The difference is that students have chance to reach upper layers with their choices. However, with the Bloom's taxonomy all students should do all activities that are defined in a course.

**Agent Function Teaching**

Agent function is a well-known problem in artificial intelligence. A simple robot design and control code can be demonstrated with agent function. In an agent function, a robotic system's perceptions and actions are decided and processed. A classical agent function definition and an example are given from Russell (2005).

An agent function concept is explained to the class of students with lecturing method. After the definition of the agent function, a simple example as Vacuum-Cleaner world problem is introduced by demonstrating technique together with lecturing as shown in Figure 2.




Percepts: location and contents, e.g., $[A, Dirty]$

Actions: $Left, Right, Suck, NoOp$

**Figure 2.** Vacuum-Cleaner world problem (Russell, 2005)

The example is analyzed together with the class about the required percepts and actions. In order to develop a control algorithm for this example an agent function concept is introduced.

```
function REFLEX-VACUUM-AGENT( [location,status]) returns an action

  if status = Dirty then return Suck
  else if location = A then return Right
  else if location = B then return Left
```

**Figure 3.** Vacuum-Cleaner agent function (Russell, 2005).

The syntax of agent function is explained and the control algorithm is traced in the class. An optimal agent function solution is shown in Figure 3. After some discussions related with student questions, the vacuum-cleaner world problem is modified with the following questions:

***i.*** Modify your agent function for a problem of: "having four numbers of locations in the environment."
***ii.*** Modify your agent function for a problem of: "the algorithm must stop when all environments are clean."

The modifications are asked in the given order and they solved one after the other. Firstly, after each question, sometime duration is allowed to students to think about the problem. After that, potential solutions are discussed in the class. The second question is asked after the solution of first question. Again, sometime is given to students to think about it.

The Robotics course and the agent function design topic is taught by using traditional deduction teaching method and it is combined with problem solving and discussion teaching strategies. Additionally, in order to increase students' interests in learning process a workshop is organized and some of the students let free to choose their example about agent function.

The class is randomly grouped into three. One group includes students that not attended the workshop, second group includes students that attended the workshop and they get a question with a given agent function problem. Lastly, the third group of students that attended the workshop and they ask to give an agent function problem. It is expected to have new agent function problems described by the student. One of the aims for this activity is to increase the students' interest about agent function design and to let the students to find their own example.

There was one ungraded workshop, one quiz, one midterm, one group project and a final examination that are planned as course activities. Each activity is graded by the course instructor. Like in workshop, the same group of students are asked to give an agent function example in the quiz where the others are asked solve a new example. Same questions are asked to the class both in midterm and final examinations by using the Bloom's teaching taxonomy of questions from simple to complex ones. Several project groups are assigned with the approval of all members.

## RESULTS AND FINDINGS

Students' course performances are analyzed in this section. First of all, the distribution of three groups in the class is illustrated in Figure 4. These three groups are randomly formed within the first-class activity of workshop. Whole class randomly and almost equally divided into three groups and they named as Not Attended, Given Example and Give an Example.

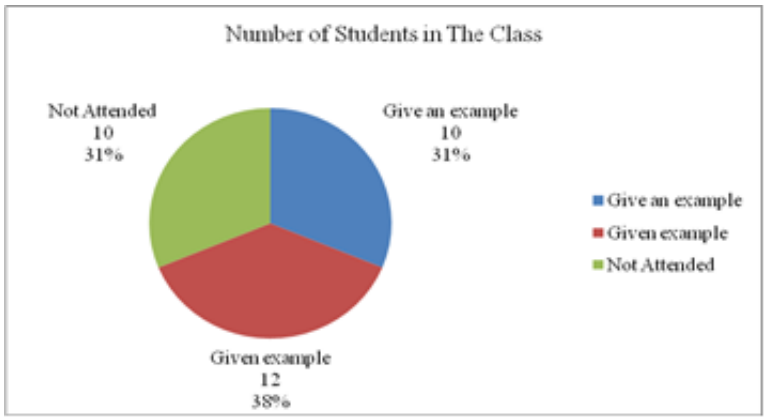



**Figure 4.** Workshop attendance distribution

After the workshop activity, a graded quiz is done in the class with a predefined date and content. Like in workshop no new example is given in the quiz by the first group but structure of agent function is correctly used. The quiz examination evaluation was out of 5 and the class averages is given in Figure 5. Significant success is seen with the students that attended the workshop.

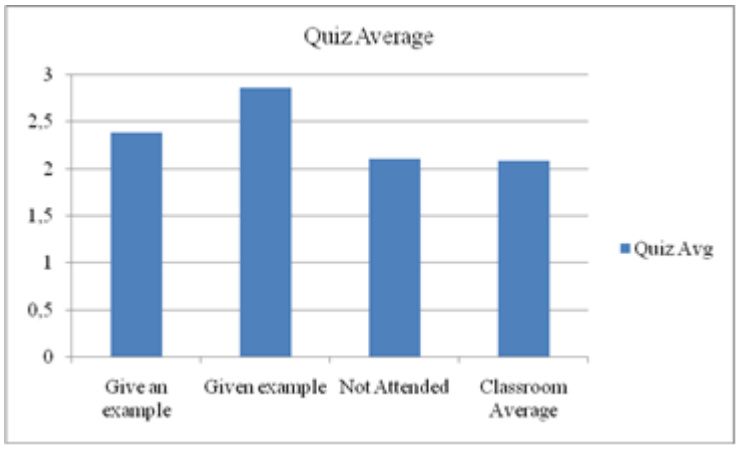



**Figure 5.** Quiz average for agent function design question

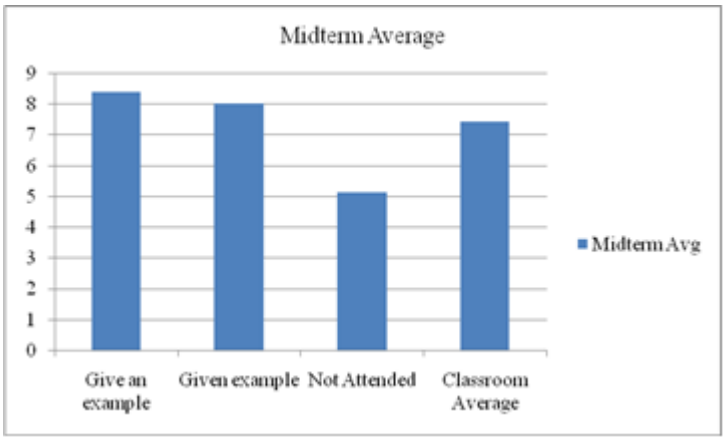



**Figure 6.** Midterm average for agent function design question

An agent function question is asked in the midterm examination. Its evaluation was out of 25 and the class averages is given in Figure 6. Significant success is also seen with the students that attended the workshop.

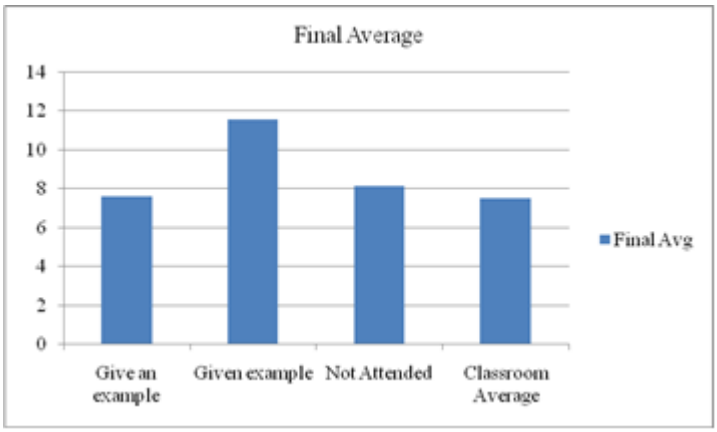



**Figure 7.** Final average for agent function design question

An agent function question is again asked in the final examination. Its evaluation was out of 20 and the class averages is given in Figure 7. The success average of Given Example group is found as the greatest one. This might be because of the students' personal learning abilities. The personal learning ability plays a big role in teaching-learning methods. It is obvious that asking to find new example has no effect on students' learning interest.

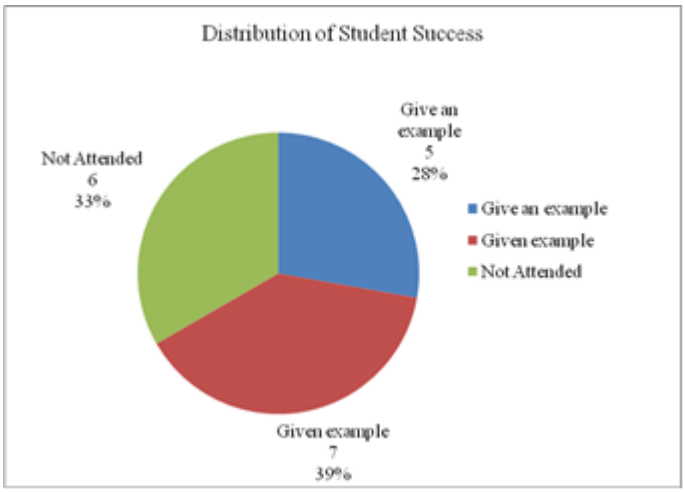



**Figure 8.** Distribution of passed students in the class

The success rates between these three groups are analyzed in Figure 8. Students that are asked to find an agent function example have the lowest passed ratio regarding the others.

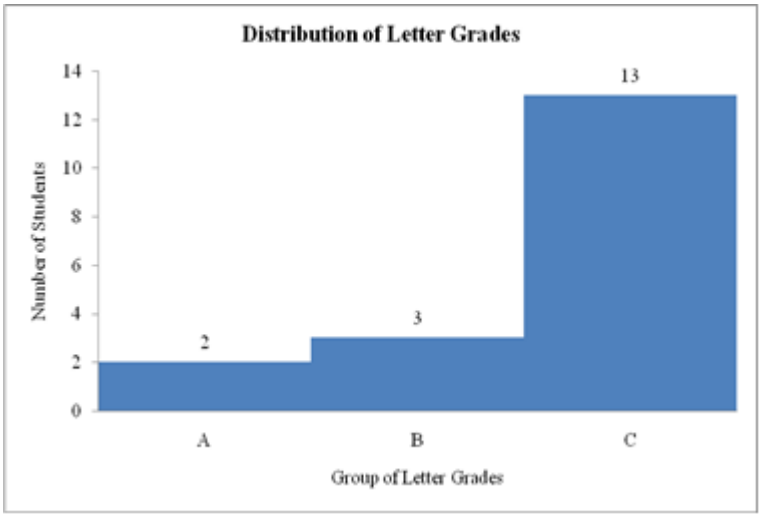



**Figure 9.** Later grade distribution of the class

The successful students' grades distribution is given in Figure 9. Only few numbers of students have higher thinking levels. It is clearly seen that the distribution of grades perfectly matches with the Layered Curriculum architecture.

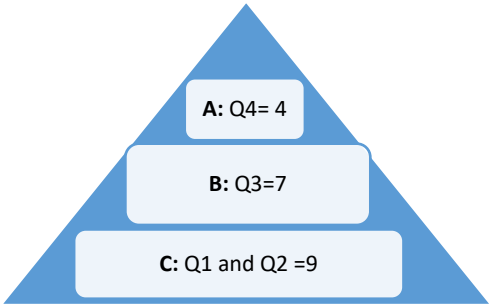



**Figure 10.** Layered distribution of agent function answers in midterm examination

In the midterm examination four questions are asked to the students. When the questions are categorized depending on the difficulty levels, they match with the three layers of the Layered Curriculum. First two questions were about basic level and 9 numbers of students can be considered as fully understand and answer these questions. Third question was about analysis level and 7 numbers of students can be considered as fully understand and answer this question. Last question was about evaluate level and only 4 numbers of students can be considered as fully understand and answer it.

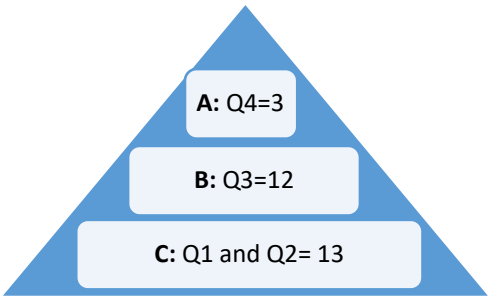



**Figure 11.** Layered distribution of student success in final examination

In the final examination four questions are asked to the students. When the questions are categorized depending on the difficulty levels, they match with the three layers of the Layered Curriculum. First two questions were about basic level and 13 numbers of students can be considered as fully understand and answer these questions. Third question was about analysis level and 12 numbers of students can be considered as fully understand and answer this question. Last question was about evaluate level and only 3 numbers of students can be considered as fully understand and answer it.

## CONCLUSION

This study analyzes the effect of chosen example for agent function design teaching in Electrical and Electronics Engineering students at Cyprus International University in 2015-2016 Fall Semester. Totally 32 students' examination scores are analyzed which are registered at the beginning of the semester.

The agent function design is one of the important topics in Robotics course in Electrical and Electronics Engineering Department. Traditional deduction teaching method was used in the class. Course content is explained and discussed via presentation. After giving the basic information about robotics, the agent function design is subject is introduced. This subject requires problem solving teaching method to improve students' understanding. From the previous semesters' experience, it is observed that students have difficulty to develop an agent function. Therefore, a workshop is organized before the quiz examination.

The students' performances show that a given example by the instructor has significant effect on students' learning levels. This might be because of an experience requirement to find a new example for agent function design problems. It is also observed that with project implementation students' performances from midterm to final examinations are also improved.

It can also be observed that the Layered Curriculum with project based learning might be the most suitable teaching approach for the Robotics course. Furthermore, to see the effect of this approach in the education of engineering faculties further research is required. There are some courses in all engineering faculties where the proposed approach can be easily implemented. Introduction to computer programming, advanced computer programming, logic design and robotics are some examples of those courses.

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## *Section 2: Educational Technology*

# TRAINING SCIENCE TEACHERS OF SECONDARY EDUCATION WITH NETWORKING: FROM WEB2.0 TO EDU2.0

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**ABSTRACT**: In this paper the development of the social networking's framework of the 'Grand Training Program' for Science Teachers of Secondary Education by the Greek PI is presented, as developed by the trainer and trainees in Mytilene. The research is a reflection case study on the training process applied to Science teachers of Secondary schools with synthesis of personal narrative of trainer and the archival material of the Program. The research aimed to those characteristics of teachers' training that made it an integral part of the education and training, simultaneously happening in many schools of Lesbos and others of Greece. The research highlighted the Web2.0 technologies exploited in science teachers' training giving to the school education evolutional extensions to Edu2.0. sub-queries were about 1. Networking supports teachers' learning, 2. Structuring a network for knowledge and information sharing, 3. Connectivity for the professional development of teachers, 4. Delivery of digital educational material and methodology for teaching Sciences. Trainees learned new techniques and methods of science teaching and applied, firstly among themselves, and then everyone in the classrooms, with his/her students, they wrote the evaluation and reflection of their training and teaching activities, published ideas, thoughts, feelings and comments of satisfaction on their Facebook wall for the 200 and more hours spent participating to the unprecedented service training of GTP.

**Key words:** Science teachers' training, secondary science education, information and communications technologies, greek major Teachers' training program

## INTRODUCTION

According the Article 5A of the Greek Constitution, everyone has the right to information, participation in the Information Society, to facilitation of access to electronically handled information, which the production, exchange and dissemination is obligation of the State. Digital literacy is imperative of the Lisbon Strategy for ensuring the key objectives of the Strategy "Europe 2020" lifelong learning, social inclusion and community integration (CEU, 2007; EC, 2009). The professional development of teachers is directly related to the continuous improvement of their educational skills and the development of their personality (EC, 2009). Teachers are mediators between a rapidly evolving world and the pupils who are preparing to enter in this world. The work of education is becoming increasingly demanding: work with more heterogeneous groups of students in relation to the past (heterogeneous in terms of mother tongue, gender, ethnicity, religion, abilities, etc.). Teachers and their trainers must use the opportunities offered by new technologies to meet the personalized learning request and teach students how to learn independently and for their whole life (EC, 2007).

In Greece, the profession of Secondary Science teacher exercised without specific education and training in didactic and pedagogy, usually empirically of the multiannual apprenticeship in the educational institutions. The Curricula of higher Education focus on the scientific knowledge and have not taken into account the introduction of this knowledge to the secondary schools. Thus, teachers, unwittingly, reproduce teaching experiences gained by the educational system that passed, which usually reflect the traditional, teacher-centered perception. In Greece, the teaching experience of the secondary teachers that has been acquired in the exercise of their profession, has not been recorded and evaluated, with consequence not to have been set a general framework for teachers' education and training, also principles for new teaching methodology but is followed the traditional, unattractive to most of the students, with numerous questions on its quality and effectiveness (ECET, 2010). By introducing innovations in teaching practice, teachers improve themselves, acquire confidence, self-esteem, more and more concrete criteria of their choices and practiced in the perception of the deepest dimensions of the events and phenomena of Science which studied in schools (Kokkos, 2008).

A significant number of researches confirm the positive impact of ICT on understanding basic concepts of disciplines such as Language, Mathematics and Science and the development of higher cognitive skills through the creation of new knowledge building conditions of the students themselves (Crock et al., 2010 in Mikropoulos, 2011). Priority of the developmental Programs of the Greek government in 2007-2015 was to strengthen and improve the quality of training of teaching staff in primary and secondary education, with emphasis in innovation and ICTs, by developing distance learning and upgrading the level of postgraduate studies in order both contribute to the production and dissemination of new knowledge in the applied Sciences and ICTs (NSRF 2007-13). The Grant/Mayor Teachers' Training Program (GTP) implemented at pilot phase in 2009-2011 by the Greek

Pedagogical Institute (PI) for teachers of Primary and Secondary Education in five regions of Greece, among them was Mytilene. The program was based on the findings of a survey of the teachers' training needs and focused on the development of flexible training models, such as e-learning, mixed in person and remotely communication, synchronous and asynchronous education etc., by involving new technologies in all school objects. (PI, 2011).

The design, construction and implementation of GTP with its support activities, as applied in the 'Grand Training Program-3rd section of Science Teachers in Mytillene', contributed to the creation of a real and virtual community of practice and learning (web2.0), where digital interaction was transformed into social, into Education 2.0. Because the concept of learning is changing rapidly in recent years, the duties of teachers are becoming more complex, requiring more planning and evaluation of courses, more connections to the everyday life and society. Teachers undertake the role of the facilitator of learning rather than the sole holder of knowledge and information in the classroom. Therefore, it is necessary to plan and organize new, dynamic and not constant learning environments, ranging from virtual to real life conditions, and transform their courses in active, participatory and students-centered learning processes (Volmary et al, 2009).

European cooperation in Education and Training for the period up to 2020 should be established in the context of a strategic framework spanning education and training systems as a whole in a lifelong learning perspective (EC, 2009). Lifelong learning should be regarded as a fundamental principle underpinning the entire framework, which is designed to cover learning in all contexts - whether formal, non-formal or informal - and at all levels: from early childhood education and schools through to higher education, vocational education and training and adult learning. Specifically, the framework should address THE strategic objectives of making lifelong learning and mobility a reality and improving the quality and efficiency of education and training (EC, 2009). Education and training systems cannot stand alone in the fight against skills shortages. Companies can work in parallel of the public sector and invest in the further VET training of their employees, and offer quality apprenticeships and jobs. Finally, what the evidence alludes to is that EU strategies should aim at longer term goals, including to invest in the key competences of basic skills of individuals so as to enable their adaptability and at the same time further encourage creativity, innovation and entrepreneurship; a stronger social dialogue needs to be built to sustain the development and utilization of skills of people within high quality jobs (PDECP, 2015).

EC (2010) believes that, in order to improve the quality of Teacher Education in the European Union, teachers could take part in an effective program of induction during their first three years in post / in the profession, to have access to structured guidance and mentoring by experienced teachers or other relevant professionals throughout their career, to – take part in regular discussions of their training and development needs, in the context of the wider development plan of the institution where they work. All teachers would benefit if they are encouraged and supported throughout their careers to extend and develop their competences via formal, informal and non-formal means, and are able to have their relevant formal and non-formal learning recognized.
"New School", as all day, innovative, sustainable, inclusive, digital, designed in 2010 by the Greek PI, aiming to students and teachers with capabilities to learn autonomously and from different sources, with problem-solving skills, to cooperate and develop interpersonal relationships, to foster accountability, sincerity and confidence, be able to plan their personal future and societal belonging (PI, 2011).

Below, the trainer describes the exploitation of New Technologies and Social Networking Web 2.0 in a target based, sustainable and integrative 'Grand Training Program-3rd section of Science Teachers in Mytilene'. It's a critical approach of the application of a digital learning community formed by 19 Science teachers of all specialties of Secondary Education, who, upon selection by the PI, had been the 3rd training section of GTP in Mytilene.

## METHODS

In this chapter is presented the development of the social networking's framework of the 'Grand Training Program-3rd section of Science Teachers in Mytillene', which developed by the trainer and trainees. The research is a reflection case study on the training process applied to Science teachers of Secondary schools with synthesis of personal narrative of trainer and the archival material of the Program. The research aimed to highlight those characteristics of the training that made it an integral part of the education and training, simultaneously happening in many schools of Lesbos and others of Greece.

The involved teachers, with their trainer, shared, parallel to the standard distributed material of the GTP, specific digital training material consisting of texts, educational software and Internet applications for the courses in Physics, Chemistry, Biology and Geography taught in schools, also the Research Projects and School Activities Projects all connected to the Science curriculum. The research material, constituted by the reflections written by the trainees at the end of every phase of seminars and the delivered material throughout the Program

implementation, was in printed and digital form, contained texts, videos, images, good teaching practices, fragments from scientific articles and books, software, digital applications, etc. on the Science courses and on didactic theory and applications.

The research sub-queries were about how networking supports teachers learning, how to structure a network for knowledge and information sharing, how connectivity can promote professional development of teachers, how to deliver digital educational material and methodology for teaching Sciences.

## RESULTS AND FINDINGS

Following are inserted interstitially, in quotation marks, some fragments of teachers' written reflections organized in the four coded categories of networking exploitation in teachers' training, by the use of web2.0 philosophy and technologies. The research highlighted the Web2.0 technologies exploited in science teachers' training giving to the school education evolutional extensions to Edu2.0. The expanding frontiers of science and the exponential increase in technological innovations will significantly affect the future, if twentieth century experience is anything upon which to construct a conjecture. In his book, The Third Wave futurologist Alvin Toffler (1980 in Wolhuter, 2011) contends that the three milestones in human history are the agricultural revolution of 10 000 years ago, the industrial revolution 300 years ago, (the second wave) and the creation of a high-technology based society (the third wave) currently taking place. Particularly significant areas of technological and scientific progress are agricultural development and transformation, biotechnology, the communication, information and knowledge revolution, and automation with robotics revolution (Wolhuter, 2011).

With the progress of training, teachers applied those learned to their classes and brought feedback to the trainer who channeling it to the response of the GTP. In this way, training of teachers and education of students was developing simultaneously, rotating reflections and feedbacks.

### Networking and Grouping the Teachers in Training

As knowledge is not transferred or accepted passively by the learner, but actively it built up, many factors can help adults to learn, such are practice, experience, examples from everyday life, analysis and links with the theory (Olssen, 1996), the "change in the new knowledge-introducing", the "consciousness of the teaching object" the "creative company", the "upgrading of culture", the "hope for change", as trainees wrote in their reflections. Active participation in the learning process, the exchange of views and dialogue developed through sincere and cooperative teacher-student relationships have proven that different people can learn in similar ways (Kokkos & Lionarakis, 1998).

For the training needs, in person and remotely process, synchronous and asynchronous, it had established a group of trainees' email addresses, a Moodle platform in e-learning.sch.gr for producing Internet-based courses, a BlogSpot for information and exchange views and two Wikispaces websites for the co-formulation of educational materials on issues of local and scientific interest. The two Wikispaces established for the concentration of educational material on the local issues "Aristotle and Lesvos" and "Sappho the Educator". Networking aimed to concentrate and deliver much and variety training material, practicing teachers in a new way of teaching and work together with their students. This applied and practicing innovative training methodology for teachers' personal and professional development can consequently improve the education they provide to their students. The learning environment of the GTP in Mytilene, real and virtual, created to facilitate active and collaborative learning processes of the learners-teachers who were invited to bridge the gaps created in schools, home, in society, between science and everyday life, and help their students to realize that Science by the use of Technology can improve the quality of life (PI, 2009).

The training in the 'Grand Training Program-3rd section of Science Teachers in Mytillene' was constructed in three levels in accordance to Adults Education Projects, those of knowledge with theoretical subjects, of skills development in practice and the attitudes change level with the combination of different methods and practices, as reported by Kapsalis and Papastamatis (2000). Working in groups provided the field for development all the three aforementioned levels. In Adult Education and Distance Learning, trainer encourages the learning effort, to raise the morale of learners by strengthening, motivation and feedback (Kokkos and Lionarakis, 1998). Within the groups of teachers, trainers and trainees' roles constantly alternated as "with these became again schoolchildren", "children need to have an active role in the teaching game ... The teacher has to be a disciple" "Everybody submits personal experience, biomes and soul in the issues which whenever addressed by the team".

The Chinese saying "I hear and I forget, I see and understand, I do and I learn" performs very well the value of experiential learning. Throughout the period of training, teachers learned capitalizing existing knowledge, biomes and experiences, reflecting upon and metacognitive the teaching practice followed so far and the improvements that can make in the future. They made suggestions for improvements of the existing school educational material, such as "not supposed to say the word 'power' in that place of the Buoyancy work sheet because for better introducing of the new notion.". "should be initial knowledge about acids", "wrong place of reference was made to the bases in this position of the worksheet" "the rope in the image should be shown how to transfer the forces" etc.

**Opening Channels to Share Information and Knowledge in Training**

Communication as a basic need and skill in the 21st century education, digital communications and, through it, social networking is gaining ground in recent years, with many teachers now, tied to global online web. Reflection takes place with the presentation of the components of digital networking trainers and trainees, highlighting the internet websites as a key tool to link trainers and trainees to access educational and training material for self-education and inclusion (EC, 2007). The training process for the teacher web communities was designed with the principles of adult education and implemented on the basis of utilization of ICTs and distance education to promote the educational innovation (PI, 2011).

Regarding the process of organization of the GTP, the PI followed the procedure: Trainers of A level designed and produced educational material for each teacher's specialty and trained the trainers of level B who, in their turn, offered training to teachers from schools in five prefectures of the pilot implementation of the Program. The communication of A and B trainers was done directly to the PI, through the dedicated website and emails. Thus, the announcements and instructions from the project manager to the secretaries, trainers and trainees who finally received all the feedback to the retrograde are distributed hierarchically. Teachers, what they learned during their four-month training, they applied slowly to the classes in an organized and consulted manner, designed and implemented teaching interventions in Science courses in schools, they made reflections in persons during the seminars with the trainers' B also through emails and received feedback from the trainer. Then, all trainers' B summarized the experience and conclusions to the PI and took again feedback.

'Grand Training Program-3rd section of Science Teachers in Mytillene', in collaboration with the trainer, beyond the mandatory, developed parallel, some educational activities in a digital learning community which they built up. On the PI page of GTP posted the entire training material created to serve the needs of the Program (http://www.epimorfosi.edu.gr/). For the 'Grand Training Program-3rd section of Science Teachers in Mytillene' Moodle platform was created to promote the asynchronous e-learning by using the Pan-hellenic School Network (sch.gr) software for producing Internet-based courses and to compensate for the lack of a central, which was announced by GTP but not finally built up. A trainee became the coordinator of the platform and created a class named MPE04MYTILINIS3 selecting one of the categories of available (http://e-learning.sch.gr/), closed to the group of trainees. The course design process followed the following steps: a. selected the unity of developing lessons available to the home page of http://e-learning.sch.gr/, b. added a new course to the setting of the eight modules, available to those who have the corresponding key. c. Trainees and trainer had the capability of downloading files and software for Sciences through URL links, d. was created a Forum for exchange of aspects, teaching material of GTP, useful addresses of scientific websites, ICTs hardware, e. emphasis was given to the IMS (Instructional Management Systems) which allows packaging digital content (documents, images, video, music files) to be viewed as a separate site, navigating digital open access books related to Science and teaching.

By building up two wikis, they collect a kind of dynamic library that can be updated and enhanced to provide additional capabilities to the users, making them in shaping the common content (Stea et al, 2011). Wikis are websites that help the co-construction of knowledge by creating and editing a number of related websites, via a web browser such as Internet Explorer and the HTML language. Wikis created to serve the design needs of the Research Projects which introduced in Lyceums as new courses to promote interdisciplinary teaching, group work, and experiential learning (Circular Ministry of Education YA97364 / C2 / 30- 08-2011).

The BlogSpot mpe04mytil.blogspot.com posted on the e-Google blogger website, utilizing ready BlogSpot's creating forms. It operated alongside the Moodle platform to meet the direct communication and understanding needs of trainees, of sharing and annotation of current information of school lives and any educational and informational questioning-answering. Main was the latest posts, and beneath them there were opportunities to comment and characterization of class post belongs (e.g. education, physics, etc.). In the right part of the page archived posts based on the popularity criteria and chronological order. Below, on the left side of the page, there were various gadgets and a lot of links for general information.

The experiential and discovery learning can now be achieved more easily than in the past with the available appropriate educational software and tools, developing internal learning motivation (Komis, 2004; Kartsiotis, 2008). Without detracting from the importance and usefulness of oral teaching, the choice of active strategies and more modern supervisory instructional media brings closer those are spatially and temporally remote (Moldstad, 1985).

**Connectivity for The Teachers' Professional Development**

Teacher education consists of a theoretical and a practical component. Originally, at the normal schools the practical component was very prominent. That was less so when teacher education relocated to teacher training colleges. Finally, at the university, at first, the theoretical moved to the foreground. The prominence of the theoretical has been dimmed in the recent past by a number of factors, and much greater value is attached to the practical. Pre-1990 university teacher education gave student teachers a liberal education, i.e. a teacher equipped to take his/her own decisions, one of the hallmarks of a professional person, rather than a person whose working day consists of carrying-out the dictates of superiors of a hierarchy (Wolhuter, 2011). Technology is probably one factor behind the shift back to the school as site of teacher education.

Many factors have contributed long to restrict the joint work of teachers, such as the traditional syllabus and curriculums, timetables, the suffocating time of teaching hours, split into 45 minutes, the varied and multiple demanding reality of each school community and each class and generally the prevailing mentality in schools. "We need collaboration among team members", "collaboration and interaction with the instructor offer equal membership", "The evolution of a teacher does not stop with the nomination". "We must constantly be developed and cultivated with new teaching methods, new school, teamwork, use PCs and interactive whiteboards, new curriculums".

The prospect of a social educational network through which can be exchanged knowledge, information, experiences, opinions, personal values and attitudes, gives additional credibility to programs targeting to groups because they help to achieve goals of the groups, which are hardly achievable on individual level (Christakis & Fowler, 2009). The members of a social network exceed themselves-for better or for worse-and become part of something much larger. They become connected. Their connectivity drastically affects in the way they perceive the human condition. At the end of the 1st team exercise, the words that trainees were written in their reflection had all the prefix co (in Greeks 'syn'): -resposnible 'synypeuthynoi', set of 'synolo' collaboration 'synergasia', consciousness 'synaisthisi', conscience 'syneidisi', complementary 'sympliromatikotita', codecisions 'synapofaseis', participation 'symmetoxi', joint management 'syndiaheirisi', composition 'synthesis', conformation 'syndiamorfosis', discussion 'syzitisi'. These constituted the contract of the Group of trainees.

Trainees learned new techniques and methods of science teaching and applied, firstly among themselves, and then everyone in the classrooms, with his/her students, they wrote the evaluation and reflection of their training and teaching activities, published ideas, thoughts, feelings and comments of satisfaction on their Facebook wall for the 200 and more hours spent participating to the unprecedented service training of GTP. Through such training procedures, participants improve the sense of them and enhance their social profile because, as technology evolves, develops also social practices and affects the relationships and the self-image (Turkle, 1996). Many studies have shown that the identity of modern people deeply influenced by participation in online communities in virtual worlds. Finishing the program, the trainees stated: "we felt cooperativeness, pleasure, satisfaction" , "we understood by widening the horizon of our cooperation, the team to creates" "we facilitated the common goal, flexibility and yielding in our opinion, the acceptance of group members", "the lack of experience, the combination of various disciplines in one, the overcoming of individualism caused us difficulties", "leaving, we took in our handfuls hope, experience, expectation, creative company, pleasant atmosphere, spontaneity, humor", "a positive experience expecting the application to classrooms".

**Delivery of Digital Educational Material and Methodology for Teaching Sciences**

and ICTs contribute significantly to teaching Sciences in schools by modeling, visualization and simulation of physical phenomena and processes and help to create dynamical learning environments that provide unique opportunities for users to observe phenomena, materials and processes which are often difficult or impossible or even dangerous to observe them actually (Stavridou, 2011). During the seminars, the traditional classroom changed and got new dimensions in cyberspace, became more attractive and efficient for the trainer and the trainees, following the pattern of modern life, with the characteristics of extremely great diversity and complexity, continuous development, due to the networking and sharing, teachers became also students, trainers and trainees.

Complementing this material posted and shared via the Moodle platform of Wikispaces, Blogspots and emails of the studied network in Mytilene, educational materials for direct use in the classroom in the teaching of Science courses. Environments for the creation of multimedia micro-worlds applications, Flash as Interactive Physics, Modellus, IrYdium, Chemistry 2000, language Logo, Java, use Visual Basic for Application, educational games and e-learning applications contributed to natural phenomena and simulation processes to perform virtual experiments through specialized software. Indicatively referred applications (phet.colorado.edu/Faraday) and nordicgroup.us, the videos and applications in the worksheets for the study of the phenomenon of electromagnetic induction made the new knowledge more attractive for the teachers in seminars and for the students in applied lessons.

Impressive outcome of the abovementioned were the micro-teachings, which designed and implemented by trainees at the end of the Program for evaluation and had tried firstly in their classrooms, which were plural and diverse multimodal teaching texts on Science subjects. Trainees exploited, with the better way, the didactic methodology they practiced, the delivered educational material, and the collaborative philosophy of co-construction they cultivated in designing teachings in Science courses in their schools, far away from those they used to do. This period of their life was the most complete of aim-centered training that they had ever received. "You never know what dynamics have each your colleague", "In the beginning (of the training seminars) you say that all the same and the same will be, but in the process often you change your mind ....".

In the reflection about the changes that trainees could make in the way of teaching at the antipode of the traditional one, expressed proposals supporting the philosophy of GTP on teaching Sciences such as the teacher to: "form working groups for his students" "guide students in laminar didactic paths to discovery of new knowledge," "pro-inform for the new teaching model to be followed", "keep in each case and discreetly the class contract", "devise alternative activities". Regarding students need to "come prepared in the educational process", "assume different roles", "set student coordinator of the educational process inside the classroom". "There is a difficulty to introduce the new ... Students are persuaded only when they are active in the new game!"

## CONCLUSION

The described training intervention of the 'Grand Training Program-3rd section of Science Teachers in Mytillene' simultaneously addressed to teachers and students, giving them the possibility of applying and integration teaching and learning innovations directly from the training seminars to the classroom education. Based on the objectives of the 'New School' reform of Greek school education system, emphasizing the development of horizontal skills of trainees and their students, the program runs transversely all school subjects. Teachers participating in virtual and real encounters of synchronous and asynchronous training, without geographic and economic boundaries, with texts, sound and images used Internet and in person teaching tools, in joint information, sharing and editing teaching materials in Science. All together designed and built the new knowledge in schools that daily change rapidly. The products of this co-construction of knowledge on modern teaching of school Science objects are uploaded on the websites up mentioned and can be basis for discussion and new partnerships of teachers to scientific and technological progress and cohesion of school communities, they can be used in any educational processes anywhere in Mytilene, near or far.

## RECOMMENDATIONS

Of course, all the efforts for renewing traditional teachings need a further glance, an overview of assessment and valuation. Many people develop, also, cautious skepticism, as Ntrenogianni (2010) writes that the digital school is not necessarily progressive, but it could be an extremely conservative school. That is why Internet, computer networks, interactive boards, information portals and digital libraries are educational tools, materials and services which, by their nature, can only "illustrate" and "represent" the new knowledge and not to "intervene" transformational into the educational purposes and goals with subsequent conversion into teaching content and curriculum.

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# BRING COSMOS INTO THE CLASSROOM: 3D HOLOGRAM

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**ABSTRACT:** Three-dimensional structures of heavenly bodies and the fact that people make observations about universe only from their vantage point on Earth make difficult to understand astronomy concepts. Basic astronomy concepts such as shapes, sizes, distances and celestial motion contain spatial thinking ability. The students who lack spatial thinking ability have difficulties to constitute these concepts in their mind. Consequently, the necessity of using different learning environments and materials supported by technology is showed up. Beyond using available instructional materials, creating their own materials not only provides students with accessing to more knowledge through research but also fosters their thinking ability with variables. Concordantly, current study aims to give an artifact implementation example designed three-dimensional hologram mechanism with simple materials oriented teaching basic astronomy topics. Hologram mechanism consists of a truncated-pyramid shaped reflector made of transparent and hard material, a video about astronomy and a screen. The study group consists of volunteer prospective science teachers (N=15) in a Western Anatolian University. The research aim is not only to create permanent artifacts but also support prospective teachers' thinking and problem solving skills using mental processes. The activity is enabled participants to use engineering and mathematic skills with designing hologram device and technologic tools via video making process. Implementations conducted with by six weekly workshops that each one takes about two hours. Participants created a permanent artifact with activity. Researcher notes and artifact assessment form were used as data collection tools. Prospective teachers' astronomy interests were supported and their astronomy knowledge increased by the artifacts designed by them. Moreover, they have begun developing spatial thinking abilities with moving and three-dimensional model which assists them to perceive depth phenomenon in universe. They experience artifact design process at firsthand and find solutions to encountered problems. Participants learned how to create a three-dimensional model. Furthermore, the activity provides opportunity to use science, technology, engineering and mathematic related skills.

**Key words:** Astronomy teaching, artifacts, 3D hologram

## INTRODUCTION

Main subject of astronomy is celestial objects. When people look at the night sky they observe stars only located in Milky Way galaxy. Beyond that had been mysterious for thousands of years due to human observation limit. First observation of extragalactic objects was made by Edwin Hubble using a large telescope in 1922-1923. Considering this dates, we are at the beginning of our cosmic journey compare with the emergence of mankind. Humans still struggle to make sense of what's out there in the Universe which lies beyond the limits of even our most powerful telescopes (Siegel, 2015). By nature of the fascinating topics it encompasses, astronomy awakens a great deal of curiosity. People are fascinated to understand different astronomy topics such as day and night cycle, lunar phases, meteor showers and eclipses.

People make observation about celestial bodies only from their vantage point on Earth. Celestial objects are so far away from earth and it does not allow people to create depth perception. We perceive heavenly objects in the sky as if they are moving in a two-dimensional plane. Besides, astronomy contains three-dimensional concepts. It is hard to understand celestial events such as moon phases, eclipses and oppositions without using three-dimensional thinking and three-dimensional geometry. Spatial thinking ability which means rotating and inverting objects in 3D when they are presented graphically in 2D have a major role learning three-dimensional concepts (Barnea and Dori, 1999). Earth-bound observations and lack of spatial thinking ability usually pose problems understand of astronomy topics (Arny, 1994; Barnea and Dori, 1999; Padalkar and Ramadas, 2011). Therefore, students find hard to understand astronomy topics as a school subjects (Yair, Schur and Mintz, 2003; Plummer, Kocareli and Slagle, 2014). In this case, using different learning environments and materials supported by technology are effective for students to enhance astronomy knowledge and to support their astronomy interest (Bakas and Mikropoulos, 2003; Mulholland and Ginns, 2008; Küçüközer, Korkusuz and Küçüközer, 2009; Uçar and Demircioğlu, 2011). Inquiry-based teaching and hands-on activities are more effective than the classical lecture-textbook approach for astronomy education from elementary to university (Percy, 2006). Within this context, beyond using available instructional materials, creating materials by student provides them accessing to

more knowledge through research and fosters students thinking ability with variables. Concordantly, purpose of the study is to conduct with an artifact-based activity with designing a three-dimensional hologram assembly.

## METHODS

### Description of the Study

This study aims to give an artifact implementation example designed three-dimensional hologram mechanism with simple materials oriented teaching basic astronomy topics. The research aim is not only to create permanent artifacts but also support prospective teachers' thinking and problem solving skills using mental processes. The participants comprise volunteer third-year prospective science teachers in a Western Anatolian University. Total number of participants is 15 (N=11 female; N=4 male). Hologram mechanism consists of a truncated-pyramid shaped reflector made of transparent and hard material, a video about astronomy and a screen. The activity is enabled to use participants' engineering and mathematic skills with designing hologram device and technologic tools via video making process. Participants created a permanent artifact with activity Data were collected for the research through researcher notes using for process evaluation and artifact assessment form using for outcome evaluation. Hologram assembly assessment form (see app. 1) developed based upon thermometer assessment form (Oğuz Ünver, 2015). The form consists of three main parts which are video, reflector and design and functionality of the hologram assembly. The researcher notes used to understand effectiveness of the activities. Researcher notes takes within the scope of three main questions: *"What are difficulties for participant during activities?" "Which skills are used by participant?" "How do activities affect participants' astronomy interest?* Implementations conducted with by six weekly guided workshops that each one takes about two hours. (See Figure 1).

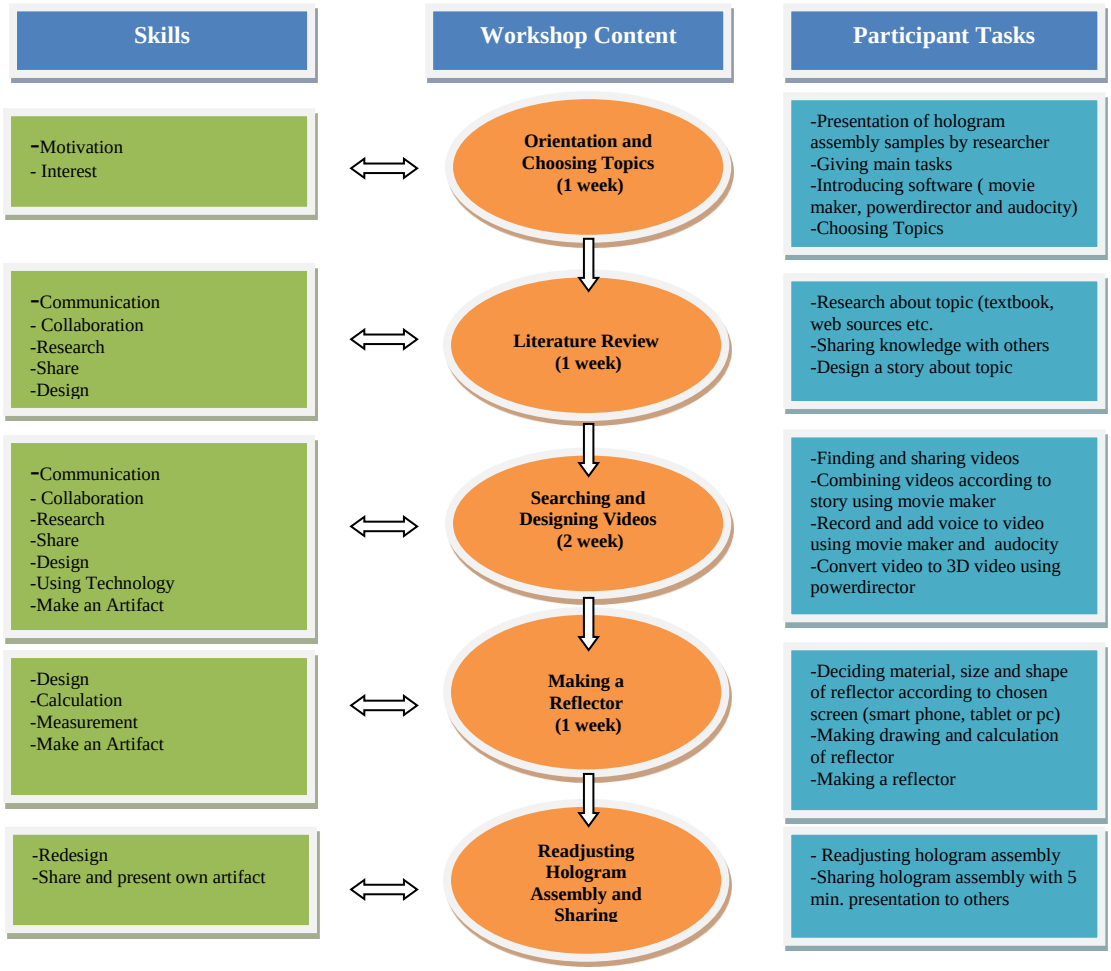


**Figure 1.** Skills, workshop content and participant tasks during the implementation

Implementations consist of five steps which are orientation and choosing topics, literature review, searching and designing videos, making a reflector and readjusting hologram assembly and sharing. Each workshop provides participants to share their knowledge, skills and experience and to do their tasks collaboratively. During workshops researchers guide participants in different ways such as the define order of tasks, lead to participants determining

knowledge and scientific knowledge and motivating them to difficult problem. The workshops support participants individual and group skills such as interest, sharing knowledge and collaboration. The primary aim of workshops is not produce the artifacts, they aim to create a collaborative and inspirational learning environment which constitutes peer learning. One of hologram assembly sample created by a participant is shown on Figure 2.

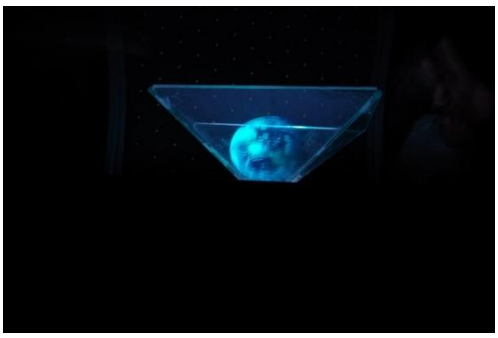

**Figure 2.** Hologram assembly sample-rotation of the earth

The quantitative data obtained from hologram assembly assessment form analyzed with descriptive statistics. The qualitative data obtained from researcher notes analyze via content analyses by two researchers.

## RESULTS AND FINDINGS

The findings of the research are presented as quantitative and qualitative results. The finding of artifact assessment form using for outcome evaluation is shown Table 1.

**Table 1.** Descriptive statistics obtained from artifact assessment form (N=15)

| **Video** | | | |
|---|---|---|---|
| **Topic of video** | Black Holes, The Sun, Artificial Satellites, The Milky Way Galaxy, The Seasons, Galileo Galilei, Lunar Phases, The Formation of Moon, Known Universe, Jupiter and Moons, Day and Night Cycle, Light, Universe Models and Rotation of the Earth (N-15) | | |
| Length of videos | Change between 2,16 and 6,15 minutes | | |
| Video contains scientific knowledge | N=12 (Yes) | N=3 (Partly) | N=0 (No) |
| Appropriate display screen | Smart Phone ( N=6), Tablet ( N=3), PC ( N=6) | | |
| Video contains depth perception | N=15 (Yes) | N=0 (No) | |
| Video contains voice | N=15 (Yes) | N=0 (No) | |
| Video is well fictionalized | N=9 (Yes) | N=3 (Partly) | N=3 (No) |
| Video quality | N=0 (Low) | N=2 (Medium) | N=13 (High) |
| Recording format | MP4 ( N=13), AVI ( N=1), WMV ( N=1) | | |
| **Hologram Reflector** | | | |
| Material of hologram reflector | Glass ( N=3), Hard Plastic ( N=3), Acetate Paper ( N=9) | | |
| Hologram reflector is portable | N=15 (Yes) | N=0 (No) | |
| Size of hologram reflector | Change between 3 and 13 cm (high) | | |
| Number of hologram reflector' faces | 4 faces ( N=15) | | |
| Hologram reflector is symmetrical | N=14 (Yes) | N=1 (No) | |
| Hologram reflector works well | N=14 (Yes) | N=1 (No) | |
| Hologram reflector is transparent | N=15 (Yes) | N=0 (No) | |
| Hologram reflector uses easily | N=12 (Yes) | N=3 (No) | |
| Hologram reflector is durable | N=12 (Yes) | N=3 (No) | |
| **Design and Functionality of The Hologram Assembly** | | | |
| Hologram assembly has low cost | N=12 (Yes) | N=3 (No) | |
| Hologram assembly can use easily | N=15 (Yes) | N=0 (No) | |
| Hologram assembly can use by independent user | N=15 (Yes) | N=0 (No) | |
| Hologram assembly is interesting | N=15 (Yes) | N=0 (No) | |
| Hologram assembly can set up easily | N=15 (Yes) | N=0 (No) | |
| Hologram assembly can store easily | N=9 (Yes) | N=6 (No) | |
| Hologram assembly has long shelter life | N=15 (Yes) | N=0 (No) | |

As seen Table 1, hologram assembles evaluated in three main themes. The video theme contains content and features of videos. Topics of videos are black holes, the sun, artificial satellites, the milky way galaxy, the seasons, Galileo Galilei, lunar phases, the formation of moon, known universe, Jupiter and moons, day and night cycle, light, universe models and rotation of the earth. There of videos has partly scientific content. The videos are different length between 2,16 and 6,15 minutes and suitable for different display screens. All of videos have depth perception which means background of video is black and contain voice recorded by participants about the relevant astronomy topic. Nine of videos is well fictionalized which means the video has appropriate content knowledge and story. Generally, the videos have high qualities and in MP4 format. Hologram reflector theme is about the features of reflector. Generally, the participants used acetate papers as material. It is flexible and easy to make reflector. Rest of them used glass and hard plastic (CD case). Relatively, these materials are fragile and hard to cut. All of reflector are portable, transparent and has four faces. The sizes of these reflectors change between 3 and 13 cm (high) according to suitable screen. Generally, reflectors are symmetrical, work well, use easily and durable because of used acetate papers. Last evaluation them is design and functionality of the hologram assembly that contains seven criteria. These criteria include the general features an artifact. All of assembles can use easily and set up by independent user. All of them are interesting, can set up easily and has long shelter life. Because of used materials, glass and hard plastic reflectors are fragile, do not fold and have high price.

The qualitative findings obtained from researcher notes were classified in terms of the three basic categories which are difficulties, used skills and astronomy interest. A part of participants' research about selected topic contains web sources. Most of the participants do not distinguish knowledge and scientific knowledge due to being away from the nature of science especially in astronomy and astrology topics. They could not internalize the criteria of scientific knowledge despite being third grade prospective science teacher. Some of participants don't have qualifications and interests for technology. They find hard to make hologram assembly especially in video process. But, participants share their knowledge, experiences and skills during workshops. That allows peering learning and learned with mistakes. They improve to use technology skills. One of participant emphasized *that* with fallowing statement. *"At first, finding videos and combining them were very hard. But now, I can use movie maker, power director and audacity software. It is easy to make video in 3D. I can prepare it in a short time. I will create a hologram about biology (Participant 4)".* Also, participants have lack of measurement and calculation skills (e.g. using ruler, angels etc). Some participant statement emphasizes astronomy interest: "*When I searching for universe I found Cosmos series. It is very fascinating. I almost watch all episodes (Participant 7)".*

## CONCLUSION

The current study allows prospective teacher to create their own artifacts using technology, mathematic and engineer skills about an astronomy topic. Prospective teachers created permanent artifacts and their thinking and problem solving skills support using mental processes to find solutions to encountered problems. Also, activity support spatial thinking abilities with moving and three-dimensional model which assists them to perceive depth phenomenon in universe. The activity is enabled to use participants' engineering and mathematic skills with designing hologram device and technologic tools via video making process. Participants learned how to create a three-dimensional model. Prospective teachers' astronomy interests were supported and their astronomy knowledge fostered by the products designed by them. A specific artifact assessment forms sample for hologram assembly were developed. Prospective teachers experienced product design process at firsthand.

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**Appendix 1.** Hologram Assembly Assessment Form

| **Video** | | | |
|---|---|---|---|
| Topic of video | | | |
| Length of video | | | |
| Video contains scientific knowledge | **Yes** | **Partly** | **No** |
| Appropriate display screen | | | |
| Video contains depth perception | **Yes** | | **No** |
| Video contains voice | **Yes** | | **No** |
| Video is well fictionalized | **Yes** | **Partly** | **No** |
| Video quality | **Low** | **Medium** | **High** |
| Recording format | | | |
| **Hologram Reflector** | | | |
| Material of hologram reflector | | | |
| Hologram reflector is portable | **Yes** | | **No** |
| Size of hologram reflector | | | |
| Number of hologram reflector' faces | | | |
| Hologram reflector is symmetrical | **Yes** | | **No** |
| Hologram reflector works well | **Yes** | | **No** |
| Hologram reflector is transparent | **Yes** | | **No** |
| Hologram reflector uses easily | **Yes** | | **No** |
| Hologram reflector is durable | **Yes** | | **No** |
| **Design and Functionality of The Hologram Assembly** | | | |
| Hologram assembly has low cost | **Yes** | | **No** |
| Hologram assembly can use easily | **Yes** | | **No** |
| Hologram assembly can use by independent user | **Yes** | | **No** |
| Hologram assembly is interesting | **Yes** | | **No** |
| Hologram assembly can set up easily | **Yes** | | **No** |
| Hologram assembly can store easily | **Yes** | | **No** |
| Hologram assembly has long shelter life | **Yes** | | **No** |

# TURN YOUR PHONES ON: USING ANDROID DEVICES TO COLLECT SCIENTIFIC DATA

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**ABSTRACT:** Data logging devices have been in use for about three decades but they have never quite developed into the automatic choice of device for taking measurements in educational contexts. This article reviews the reasons for this, citing difficulties with setting up, dealing with the software, and overcoming hardware incompatibilities. The literature suggests that these factors have discouraged many science teachers from embedding data loggers into their teaching. Research by the industry shows that 80% of teenagers now possess Android devices in the form of a smartphone (cell phone) or tablet, and many schools have introduced schemes which supply pupils with their own tablet device for use in lessons. Android devices are now supplied with a range of sensors which can be relatively easily used for the capture of useful data in the Science laboratory. This paper evaluates four experiments carried out using a smartphone to collect the data. The experiments are described in detail, and the errors are analysed to evaluate the effectiveness and accuracy of the device in each experiment. The measurements were taken making use of Apps which were downloaded free of charge. The Apps were used in collecting data to measure audio frequencies, magnetic fields from an electromagnet, the acceleration of a moving body, and the coefficient of restitution of a bouncing ball. Data and images are presented to enable the audience to carry out and extend the experiments for their own use.

**Key words:** Smartphones, data logging, ICT, Android

## INTRODUCTION

Computers were originally introduced into the UK curriculum in the early 1980s (although some had been in place earlier than that where schools were able to hire time on mainframes, e.g. at neighbouring universities). Since then as computers have increased in sophistication, speed and capacity, more and more educationalists have made use of them in their teaching.

The development of the personal computer since the 1970s has resulted in widespread use of computers in UK education after numerous policy initiatives from successive governments. However, Hammond (2014, 195) notes that while schools have invested in infrastructure, much of the investment has resulted in "an overemphasis on 'office' software". Policy and practice have therefore tended to lead away from the use of ICT in practical settings, while Wastiau et al (2013, 17) reports that "Digital resources such as … data logging tools … are still very rarely used by students during lessons".

However, Wastiau et al (2013) found that between 2006 and 2013, access to educational technology had roughly doubled, with broadband access available in 95% of EU schools. In the EU, there are approximately five pupils for every computer. More and more pupils are taking their own smartphones and tablets to school on a daily basis. For example, 65% of UK teenagers (age 12-15) have a smartphone (Ofcom, 2014).

While it is clear that the use of technology in science has not reached the saturation that might have been envisaged some years ago, when dataloggers were introduced, much time is spent, even in Science lessons, making use of computers as data searching or data analysis tools. But the use of computers for datalogging has been hampered by various issues – the rapid development of devices has led to compatibility problems, with new resources unable to make use of old software and vice-versa, and little research has been done to explore data logging practice, although Hammond (2014) asserts that while data logging devices allow for the capture of data in either difficult or remote circumstances, the exercise of data collection becomes an end in itself, rather than the analysis of the collected data being the focus of the exercise.

This article is not new in proposing the use of smartphones in collecting scientific data – see for example Monteiro et al (2016), Egri & Szabo (2015) and Patrinopoulos & Kefalis (2015). Smartphones now contain a range of sensors, enabling them to collect ambient data (temperature, humidity, pressure, light, sound level), as well as physical data (acceleration, magnetic field, sound frequency). However, most of these examples make use of in-house expertise in developing the necessary software to access the data. I was more interested in enabling students to obtain data free of charge, and without having to develop software skills that were not relevant to the subject

being studied. I therefore explored application software (apps) which were available free of charge through either Google Playstore or Apple iStore. There are certain limitations involved, in that the apps are often produced without the detailed subject knowledge required to make sense of the data, and this can sometimes make the collected data difficult to record and analyse. However, final-year degree students studying Physics as part of their teacher training programme made frequent use of various apps when they completed a Physics investigation module. A high proportion of these students would use their smartphones first of all to take photographs of apparatus, and some discovered useful apps which enabled them to make use of their smartphone as the primary data collection instrument.

## RESULTS

I describe here four experiments making use of some of the sensors available within most smartphones produced in the last five years, reviewing the experimenter's experience in collecting and analysing data. It was a precondition of the exercise to make use of apps that were generally available free of charge. The premise is that teachers might wish to encourage their pupils to use these apps for themselves, and a range of apps has been chosen to demonstrate how they might be applied across a range of abilities and ages. I then review some of the practices carried out be the final-year students in their Physics investigations.

The four experiments below have been chosen to provide a balance between 'quick-and-easy' experiments requiring little set-up, and those which require a degree of analysis before they can be utilised.

### Magnetic Field

App: Physics Toolbox Magnetometer (Vieyra software)

At 11$^{th}$ grade (age 16-17), Physics students study the effect of magnetic fields on electron beams, and a classic experiment in this field uses a pair of Helmholtz coils to generate a suitable uniform field. The formula for this is beyond the scope of most courses at this stage, and yet it is usually quoted and used in order to calculate the value of the field used in the experiment. Here, I used the Magnetometer app to measure the field between a pair of Helmholtz coils, and compared it with the value calculated from the formula (see appendix for further details).
A screenshot of the display is provided below.
Calculated value: $4.17 \pm .05 \times 10^{-3}$ T
Measured value: $4.16 \pm .04 \times 10^{-3}$ T

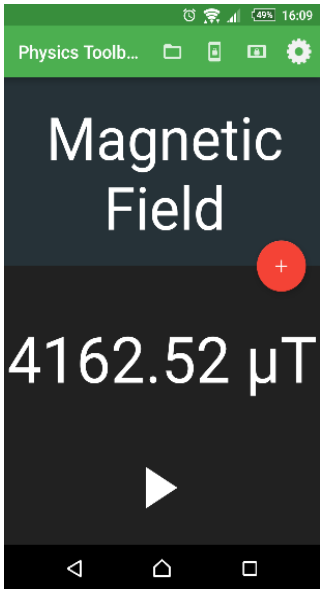


**Figure 1.** Screenshot from Magnetometer app

### *Discussion*

The app is very easy to use; the only issue is determining the limitation of the sensor when its value is displayed to six significant figures. I took the uncertainty to be of the order of the Earth's magnetic field, which is approximately 40 µT. It also takes a few moments to identify the best position to hold the smartphone in order to take the optimum reading – this will vary with the position of the sensor within the smartphone used. Accuracy appears to be very good.

**Heart rate**

App: Unique Heart Rate Monitor (Meet Your Need Production). This is a very straightforward standard experiment which can be carried out in classrooms to investigate the effect of various factors (e.g. exercise, caffeine intake) on heart rate.

This experiment is very simple to set up and run: heart-rate readings were taken every minute or so before, during and after drinking a cup of strong coffee. The app measures heart rate using its camera and lamp to detect light reflected from a fingertip – presumably detecting changes in the blood flow.

The graphing is not ideal, since it simply records values in the order they are taken. These can easily be transferred to a spreadsheet and displayed as below:

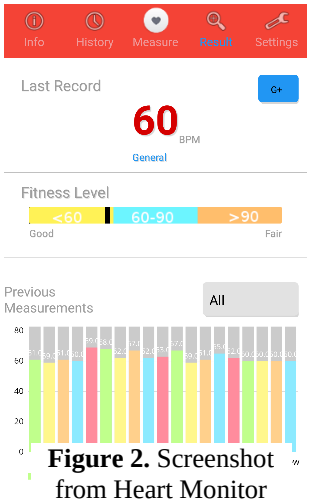


**Figure 2.** Screenshot from Heart Monitor App

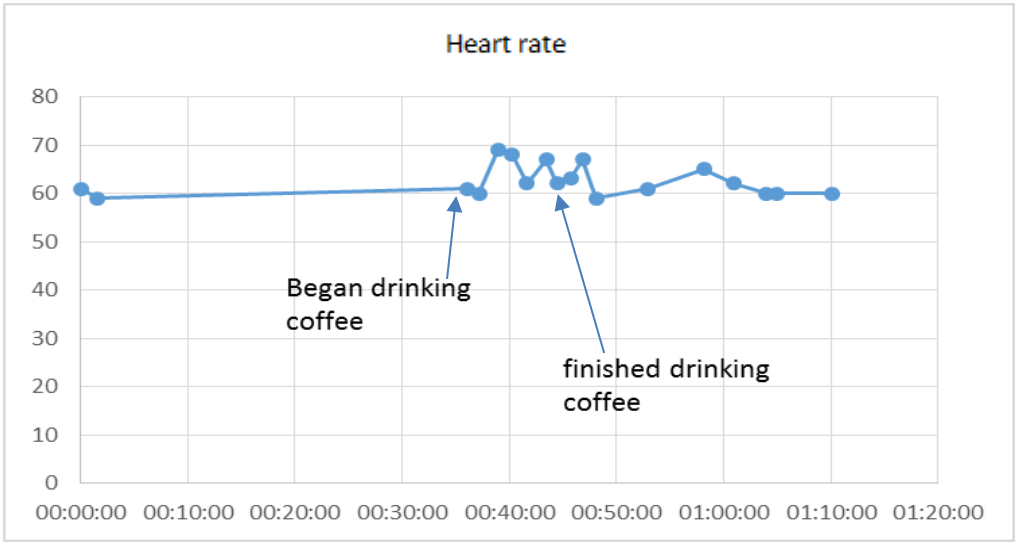


**Figure 3.** Graph of heart rate against time

***Discussion***

Data must be recorded by hand (or each reading could be recorded on a spreadsheet running on the smartphone). The app is sufficiently sensitive to demonstrate some effect from the drink, although more work would need to be done to confirm this. It is not clear whether the changes to heart rate are a result of the drink, or the effect of the experimenter's anxiety to produce results! An alternative would be to perform some simple exercise such as walking up a flight of stairs.

**Ball Bouncing**

App: Ball Tester (Solbacca) This app uses the sound detector in the smartphone to test the resilience of a ball. In this case a tennis ball was used, but the app allows for other types. It has been written to test balls from various sports against that sport's governing body regulations. By timing the gaps between successive bounces, the software is able to calculate the coefficient of restitution. Most governing bodies require that balls dropped from a specified height most bounce to a level within a given range. This app has taken the information from these regulations so that the data can be used to determine whether the ball meets the regulations.

In the reading displayed here, a previously unused tennis ball was dropped from close to the regulation height onto a solid floor. Figure 4 shows that the ball bounced to a height within the regulations (at the top end). It takes only a little practice to arrange for the ball to fall from a suitable height, although in actual fact providing that the app is able to record at least three bounces, it is able to calculate the coefficient of restitution. According to ITF regulations (ITF 2016) the ball must bounce to within 1.35-1.47m after being dropped from a height of 2.54m. This represents a range of values for coefficient of restitution between 0.73 and 0.79.

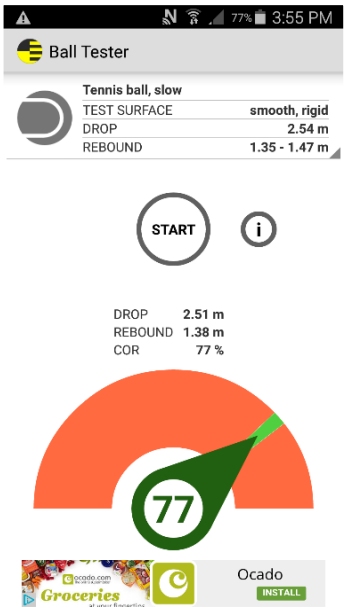


**Figure 4.** Screenshot from the bounce of a tennis ball

***Discussion***

The value calculated here ('77%') does not quite match the data displayed. These figures yield a value of 0.74 (see appendix), an error of about 5%. It is probable that the software calculates the coefficient of restitution directly from the time intervals between successive bounces, and that the displayed value of 77% (or 0.77) is derived from these figures. The error may due to the value of g used in the calculation, which is not stated in the app's documentation.
This exercise would prove useful to a group of students covering a mechanics course at about grade 11 requiring detailed use of equations of motion to derive the necessary formulae. Comparing the data with that collected using a stopwatch or timing gate would be interesting.

**Measuring Acceleration**

App: Physics Toolbox Accelerometer (Vieyra software). The use of a smartphone as an accelerometer is an inviting proposition – there are many situations in which data can be collected – for example in lifts, cars and aeroplanes. The software gives instantaneous values of acceleration or g-force in each of the three dimensions. In effect, in g-force mode the device is acting as a levelling instrument as it gives a constant value which alters as the device is tilted. In acceleration mode, it again gives values, this time in $ms^{-2}$, although these values flicker constantly as a result of random vibrations. The app also allows the user to record data through 'record' and 'stop' buttons. A graph of any or all for the values is displayed graphically as long as the phone is switched on. The time axis is updated continuously as the graph scrolls across the screen.

In this experiment, a dynamics trolley was accelerated along a friction-compensated runway by means of a force provided by a falling weight. (See figure 5). The acceleration of the arrangement was calculated from the size of the falling mass and from the mass of the combination. This was then compared with values obtained by the accelerometer app.

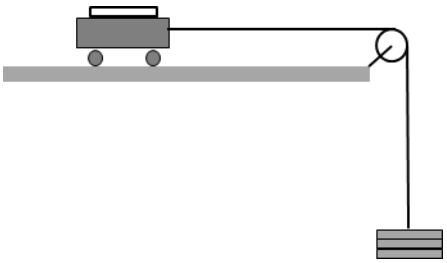

**Figure 5.** Experimental arrangement for measuring acceleration

With the mass of the trolley and smartphone reaching nearly 1kg, forces of 2N and 10N were used to accelerate the trolley. The smartphone was laid on a cushioning pad (bubblewrap) to absorb vibrations, and held in place with rubber bands to avoid the risk of throwing the phone and damaging it. Laying the phone horizontally meant that acceleration would take place in the y direction. x and z values should be zero. The smartphone was set up to

record, released, and allowed to run into a barrier. Once the data file has been loaded into a spreadsheet, nul data either side of the journey can be discarded.

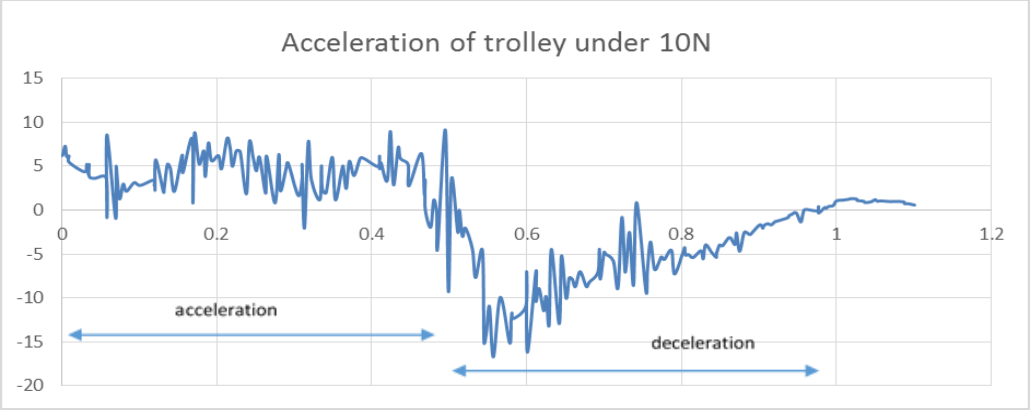


**Figure 6**. Graph of acceleration against time for moving trolley

Graphs of the data immediately show that there is a significant problem with vibration – the sensitivity of the device is so acute that the values from the vibrations tend to swamp the actual data, and although a value can be obtained which approximates to the predicted value, this can only be achieved after a significant amount of data manipulation, which undermines the task considerably. As can be seen in figure 6, the graph shows distinct phases of acceleration, deceleration and rest.

In the acceleration phase, there is significant vibration about the expected value of about 5ms$^{-2}$, and it will be noted that the standard deviation of the acceleration values is enormous, leading to a value with very little confidence. A number of techniques were tried to smooth the data, including moving averages, and eliminating extreme values, each of which brought the accelerometer value closer to the calculated value. (See appendix for further treatment)

**Table 1.** Comparison of measured and calculated values of acceleration for an accelerating trolley

| Apparatus | Driving force (N) | Mass of trolley (kg) | Measured values | | | | Calculated values |
|---|---|---|---|---|---|---|---|
| | | | Before smoothing | | After smoothing | | |
| | | | acceleration (ms$^{-2}$) | Standard deviation | acceleration (ms$^{-2}$) | Standard deviation | acceleration (ms$^{-2}$) |
| Dynamics trolley | 9.92 | 0.92 | 4.3 | 2.5 | 5.3 | 1.1 | 5.14 |
| Dynamics trolley | 1.95 | 0.92 | 1.3 | 1.8 | 1.7 | 0.5 | 1.74 |
| Air track | 0.243 | 0.29 | 0.8 | 0.5 | 0.9 | 0.3 | 0.77 |

The experiment was repeated with an air track. Because of the sizes of the apparatus, the driving force and masses were very much smaller than for the dynamics trolley, and even though the resulting graph was much smoother, because the values were smaller, the standard deviation of the results was still much too high.

Table 1 shows the values obtained from the accelerometer before and after data smoothing. The data smoothing had a mostly positive effect on the measured value of acceleration, and significantly improved the standard deviation. The most reliable result was, as might be expected, the first row, in which the driving force and resulting acceleration were quite high.

***Discussion***

Unfortunately, with this app the experiment became about the data manipulation and not about the experiment. Observed in other moving objects such as aeroplanes and lifts, the graphs produced by the app are swamped by

vibrations. Other apps demonstrate the same difficulty and experimenters such as Egri & Szabo (2015), who describe a similar experiment on a trolley oscillating between two springs, accessed the data directly from the device. This was beyond the scope of this exercise, which has the aim of evaluating freely-available software. Close examination of the data shows that readings are taken in less than 1ms, and because the gyroscope is tiny, values from quite modest vibrations can be very high. To make better use of this sensor, it would be better to smooth the data on collection.

**Summary of Investigations by Undergraduate Students**

One of the final-year modules at Edge Hill University for trainee teachers undertaking a degree in Science (Physics) with Qualified Teacher Status is a Physics investigation. Students are invited to choose a topic to investigate, and many take advantage of the features of their smartphones to collect data. There follows a brief summary of some of the projects that have successfully been run.

***Rotational Dynamics of Pool Balls***

Software: Hudl (Ubersense) available from Apple iStore

In this investigation, the rotational and translational KE and momentum of a cue ball and object ball were measured before and after a collision. The slow-motion video of the interaction was analysed to measure the movement of the two striped pool balls. Figure 7 shows three stills from the motion of a cue ball (brown) which runs down a ramp at the top of the photograph, approaches the object ball, comes to rest in the same position as the object ball moves away, and then starts to move again as the rotational momentum is converted into translational momentum. The student was able to measure to a high degree of accuracy in order to account for the potential energy of the cue ball while it was held at the top of the ramp.

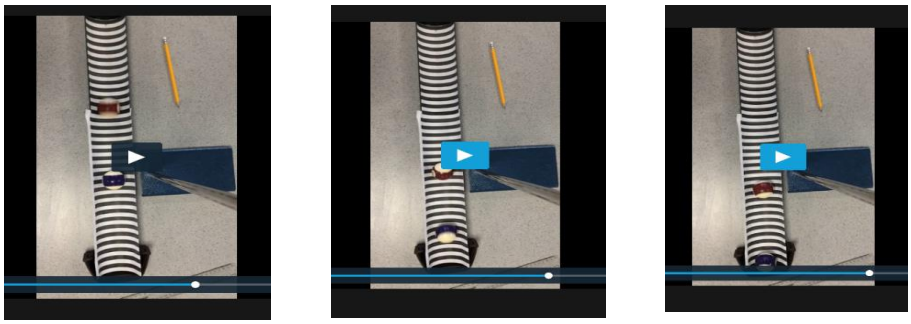

**Figure 6.** Motion of two striped pool balls as the cue ball (brown) approaches and strikes the object ball (blue)

***Sound Frequency***

App: Frequency Analyser v.1.2.04 (José Antonio Gómez Tejedo)

This student investigated the resonant frequency of wine glasses and needed a quick and accurate way of measuring the sounds generated. The Frequency Analyser app was tested and found to be accurate to at least 1% and enabled the student to quickly measure resonant frequencies.

***Sound Levels***

App: Decibel 10$^{th}$ (SkyPaw)

To test the interference patterns generated by a surround-sound system, the student built a model studio in which four speakers were situated so that he could map the sound levels around the room. He was looking for the best part of the room to sit in and found that this varied according to the frequency of sound used. He used an iPhone, which was of a suitable size compared to the size of his model room, to record the data and he found that he could position the device systematically at evenly-spaced locations about the model.

***Using Photography***

App: camera supplied with smartphones, including video playback facility.

A significant number of students have used iPads or Android devices to analyse the motion of a variety of moving objects, including parachutes, bodies falling into water and toy electric cars. Analysing the motion of these bodies is made easy by taking freeze-frame images of the object as it reaches its highest/lowest point, and solving scaling problems to arrive at an accurate value for distances covered provide extra interest and challenge. Students also routinely take photographs of the apparatus they are using as the project develops so they are in a better position to recreate the arrangement week-by-week. Purists may prefer a return to reliance on line drawings, but for me there is significant experimental integrity to this technique, and encourages good experimental design and record-keeping.

## CONCLUSION

There is at the moment no perceived standard for data logging in schools, and in Higher Education institutions data logging tends to be carried out by devices designed or programmed in-house. Apps provide a convenient, and for students, cheap alternative to solving some of the data collection problems they face. As a result, these students are encouraged to develop better experimental design, and to consider more closely the accuracy and reliability of the results they record. Data logging has often been seen as a means to an end, and the idea that the fundamental purpose of data loggers is to collect data where it is difficult or dangerous to do it manually. The experiments described here offer solutions where the data collection is otherwise problematic – generally because it is either inherently difficult for young people to carry out manually (e.g. heart rate) or because the observations are too rapid (experiments involving motion), or unnecessarily complicated (measuring as opposed to calculating magnetic field). Or because the smartphone is just so convenient and easy to use, (measuring sound levels, video recording). More to the point, students have these devices and love to be using them.

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## APPENDIX: TECHNICAL DETAILS ON THE HARDWARE AND SOFTWARE

Smartphone used:
Sony Experia Z5 running Android version 6.0

**Magnetic Field**
App: Physics Toolbox Magnetometer v1.4.1 by Vieyra software

The Helmholtz coils are commonly available in UK schools with a radius and separation of approximately 7cm.

Formula used for calculating the field in a pair of Helmholtz coils:

$$B = \left(\frac{4}{5}\right)^{\frac{3}{2}} \frac{\mu_0 nI}{R}$$

Where $\mu_0 = 4\pi \times 10^{-7}$ TmA$^{-1}$
Values used here: n=320 turns; I=1.00±0.02A; R=6.9cm

The limitation appeared to be related to the steadiness of the current, and to the measurement of the diameter of the coils between the centres of the windings. Most apps are unable to deal with fields much higher than this. Some automatically cut out beyond about 5mT, others give false readings. In order to carry out a complete experiment with an electron beam, it may be best to measure B at a lower current than is used with the electron beam and scaling it up.

Calculated value of B = $4.17 \pm .05 \times 10^{-3}$ T
Value measured by App = 4162.52 μT, or $4.16 \pm .04 \times 10^{-3}$ T

Limitation: The Earth's magnetic field is approximately 40 μT. The number of significant figures displayed is unrealistic – three is the maximum allowable here.

The app is best used in 'total field' mode, where it combines the x, y and z components into a single reading.

**Heart Rate**

Software: Unique Heart Rate Monitor v1.26 supplied by Meet Your Need Production.

Data appears accurate to ±1, as compared with manual measurement.

**Ball Testing**

App: Ball Tester version 2.0.0 (Solbacca)

Allows testing of various types of sport ball, including tennis, golf and basketball.

For a ball dropped from a height H and returning to a height h, coefficient of restitution e is given by

$$e = \sqrt{\frac{h}{H}}$$

Using the equation

$$s = ut + \tfrac{1}{2}at^2,$$

it follows that for a ball starting from rest at height H and taking $t_H$ seconds to reach the ground, it then bounces to a height h in $t_h$ seconds. (The interval measured by the device = $2t_h$). The coefficient of restitution is given by

$$e = \frac{t_h}{t_H}$$

Hence the app is able to calculate e from the intervals between the second and third bounces (which are $2t_H$ and $2t_h$ respectively). It is likely that the app calculates e from these two values, and then works backwards to give values for h. The value of g used in the calculation is not given in the documentation.

**Measuring Acceleration**

App: Physics Toolbox Accelerometer v1.4.1 (Vieyra software)

The force provided by the falling mass m= mg

Slotted masses were used, and their masses were confirmed using an electronic balance. Thus, the force could be known to a high degree of accuracy (better than 1%). The expected acceleration was calculated for each journey using

$$a = F/M,$$

where M is the mass of the trolley/smartphone plus the falling mass.

Data were smoothed by eliminating extreme data. Results which were greater than double or less than half of the mean were ignored on the assumption that these were anomalous values caused by vibrations as the trolley travelled along the runway. The standard deviation and mean were retaken after this process.

The author is not well-versed in statistical smoothing techniques, so my apologies for any offence caused by this crude methodology! A simpler solution would be to design an app which smoothed the data at source.

# DIFFUSION OF M-LEARNING: SAKARYA UNIVERSITY CASE

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**ABSTRACT**: Mobile learning (M-learning) is considered as the next generation of e-learning using mobile technologies to facilitate education for teaching and learning purposes, anywhere and anytime. This paper analyzes seventy college students selected randomly from a state university in predicting their acceptance attributes based upon Diffusion of Innovation (DOI) framework towards using the m-learning. The objectives of this research are to determine the level of usage of mobile learning and to identify the factors that the learners' intentions to adopt are of relative advantage, compatibility, complexity, observability, and trialability. The research uses standard instrument to capture students' responses on the five basic constructs of DOI model that includes relative advantage, compatibility, complexity, observability and trialability. The data is analyzed through Smart-PLS. The PLS allows the researcher to test the relationship within the measures and the hypothesized relationships between the measures simultaneously. The findings indicate that the relative advantage and compatibility are the significant determinants of the adoption of m-learning technology. The explanatory power of model indicates that 42% of the total variance towards adoption intention is explained showing the moderate parsimony of the model. Based upon the conclusion, some pedagogical recommendations are made for the relevant authorities.

**Keywords:** m-learning, college students, diffusion of innovation, DOI, Sakarya University

## INTRODUCTION

Mobile learning (M-learning) is considered as the next generation of e-learning using mobile technologies to facilitate education for teaching and learning purposes, anywhere and anytime (Nasiri and Deng, 2009). M-learning is a relatively new tool to provide teaching/learning approach to the expanding world of distance learning options but also support learners as an additional source of knowledge, with the help of small portable computing devices including smartphone and other similar types of handheld devices (McConatha et al., 2007). Oblinger (2012) made a further step by suggesting to the universities and institutions of higher learning that they must change from using technologies that only changed the delivery of content to a model that supported collaboration, interactivity, and immersion.

Mobile devices are found to be much more affordable than desktop computers and less expensive access to the Internet (even if the cost of connection is higher) (InfoDev, 2010). This increasing use of mobile devices in education enhanced by advances in mobile technology was studied by Fozdar and Kumar (2007) and Meister (2011). Nassuora (2013) reported a research that stated nine different activities students' performance in higher education setting, with their mobiles (Kennedy et al., 2008). However, the benefits gained from mobile services depend on the intentions of the students to use them for education purpose (Khanh & Gim, 2014).

Information technology and the Internet have dramatically increased the convenience of accessing information for the students and general public. Colleges have begun to experiment with the application of mobile technology. However, there are segments of the population who have neither access to nor have accepted recent innovative information technology such as mobile learning, mobile access to the Internet, and mobile information access (Horrigan, 2008a; Horrigan, 2008b; Jones & Fox, 2009; Madden, 2008). Wang and Shih (2008) suggest we need to ensure that there are no groups underrepresented or without adequate access to information. Marshall (2008) further suggests that the digital divide between those with or without innovative
technology should be further investigated.

The rapid development of mobile technology and higher education student and faculty ownership of mobile devices with Internet access have expanded communication methods, opportunities for collaboration, access to traditional learning, and access to information resources. Innovations in cell phones and other devices allow students to have mobile access to academic email, library staff, podcasts, videos, Internet information resources, course documents, and peer collaboration on projects. However, mobile learning and mobile technology acceptance research using diffusion theories such as Diffusion of Innovation (DOI) is limited (Medlin, 2001). In particular, there is a lack of research using diffusion theories on whether college students plan to use or are

currently using mobile devices to support their learning or to access the resources provided by higher education libraries.

Researchers across the globe have studied these theories for various technological innovations such as for e-learning context (Chang and Tung, 2008; Ndubisi, 2004; Lee, 2006), for online shopping (Vijayasarathy, 2004) and for Web- based information systems (Yi and Hwang, 2003). The m-learning is relatively a new field in Sakarya especially among students of a state university, up to our knowledge, no prior studies has been undertaken within the context of a state university students' intention to use the m-learning. So, this paper tries to fill-in the gap by validating the Rogers' DOI to study the Sakarya university students' adoption to use Smartphones for educational purpose.

## THEORETICAL FRAMEWORK AND DEVELOPMENT OF HYPOTHESES

This section begins with a brief discuss about Roger's DOI and some related literature. Then our study's theoretical framework is presented and tried to identify what factors might influence adoption of mobile learning.

### Diffusion of Innovation (DOI)

According to Rogers (2003) an innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption. Diffusion of Innovation Theory is based on this definition and introduced the perceived characteristics of innovating; relative advantage, compatibility, complexity, observability and trialability. DOI believes that innovation characteristics are the main determinant of innovation diffusion (Zhang et al., 2012) and they are used to predict the implementation of new technological innovations and clarify how these variables interact with one another (Gao, Krogstie and Siau, 2011). The central of this theory is the process in which an innovation is communicated among the member of the system

Since proposed, Roger's model has been widely used in research of adoption of new technologies. Researchers using this sociological theory try to identify key characteristics of technological innovations and their impacts on adoption behavior (Datta, 2011). As this theory aims to explain how innovations are taken up in a population, Moore and Benbasat (1991) also stated that the differences among these perceptions may lead to different user adoption behaviors. Regarding this context, all the characteristics can be crucial in itself. For instance, if someone feels that the new very innovative and useful software is unsurely using, she/he will immediately give up trying it. Only become an innovative software may not always enough criteria for acceptance of users' adoption. Because many researchers have argued that DOI is the best theory for studies conducting in educational environment (Medlin, 2001; Sahin & Thompson, 2006). In this study, we prefer to use this theory to examine the acceptance of m-learning among the higher education students in Sakarya University. Five significant characteristics will be discussed in detail in the following section.

### Related Literature on Technology Acceptance

Information systems (Davis, Bagozzi, & Warshaw, 1992), library information studies researchers and practitioners (Kim, 2005; Park et al., 2009; Spacey, Goulding, & Murray, 2004; Starkweather & Wallin, 1999; Totolo, 2007), and education researchers (Cetron, 2007; Dasgupta, Granger, & McGarry, 2002; Lin, Chan, & Jin, 2004; Williams, 2009) have paid considerable attention to technology acceptance. Hendrick and Brown (1984) define technology acceptance as a person's psychological state in regards to their voluntary use of or intention to use a specific technology. Venkatesh, et. al., (2003) describe research into technology adoption, acceptance, and use as "the most mature research area in contemporary information systems research literature" (p. 426). However, technology acceptance research related to mobile information technologies using information systems (IS) theory is very limited, and researchers such as Wang, Wu, and Wang (2008) suggest that further research is needed on the acceptance and use of mobile learning using traditional IS models. Mobile technologies provide new methods for accessing and interacting with information and broaden the means of communication and collaboration among students and between faculty and students.

The design, development, distribution, implementation, and support of technology are expensive investments for institutions such as colleges. The only way innovative information technology will reach its full potential and support this is if students and faculty accept and value it. There are numerous IS theories and models designed to assist in understanding how and why people accept technology and the intention to use and actual use of it. For instance, technology acceptance theory has been used as a framework to examine library staff attitudes toward the Internet (Spacey, et al., 2004), acceptance of web-based subscription databases (Kim, 2005), acceptance of digital libraries in developing countries (Park, et al., 2009), faculty responses to library technology (Starkweather &

Wallin, 1999), social inclusion of digital libraries in academic and clinical settings (Adams, Blandford, & Lunt, 2005), and the role of self-efficacy in electronic library usage (Aafaqi & Ramayah, 2004).

Venkates et. al. (2003) describe technology acceptance research as the most mature research area in IS literature. Taylor and Todd (1995) state that assessing the value of information technology to organizations (e.g., colleges, universities, libraries, public schools) and understanding the determinants of that value are keys to acceptance, integration, and use of the technology. To address this concern, there have been numerous theories and models designed to assist in understanding information technology acceptance, seeking, exchange, and use. Researchers have used theories like the Technology Acceptance Model (TAM), the Theory of Reasoned Action (TRA), The Theory of Planned Behavior (TPB), and Diffusion of Innovation to better understand the diffusion of innovations, how and why technology is accepted, and the intentions of individuals to use and the use of technology (Ajzen & Fishbein, 1980; Dillon & Morris, 1996; Lee, Kozar, & Larsen, 2003; Lucas & Spitler, 1999; Rogers, 1995; Venkatesh, et al., 2003).

**Related Literature on M-Learning and DOI**

As a result of a detailed literature research, it was seen that there is lack of study relevant about m-learning using DOI. Celik et al. (2014) developed a mobile learning adoption scale (MLAS) on the basis of DOI. The reliability of the scale was determined through item, test-retest reliability and internal consistency analyses. Total correlation for this scale was positive. Another study about online learning in higher education, Shea et al. used Roger's model to explore the adoption and diffusion of online teaching in higher education. They reached 913 professors from community colleges, four year colleges and university centers to test what factors have significant effect on faculty satisfaction on online teaching. As a result, they indicated that interaction, technical support and opportunities are the key factors (Shea, Pickett & Sau Li, 2005).

Researchers frequently prefer combining the theories to explain the user acceptance of m-learning. For example, Alharbi and Drew (2014) integrated Unified Theory of Acceptance and Use of Technology and Information System Success Model to develop a framework that assist in understanding students' behavioral intention to use m-learning systems in a higher education settings. Pina (2015) explained the perceptions of professors about using mobile devices. Through exploratory interviews based on DOI and related studies18 professors made their consideration. Teacher interest and institutional support are determinant as the most significant factors on acceptance of m-learning. Another study conducted with the combination of Extended Technology Acceptance Model (E-TAM) and DOI (Cheng, 2015). Results show that learners can judge m-learning by how well it meets their perceived compatibility and they will regard m-learning as a useful.

Contrary to the existing literature, our study aims to explain user's m-learning acceptance by using only DOI. For further studies, another least preferred such as Motivational Theory or Information System Success Model can be used to clarify perceptions of students or academic staff towards to m-learning.

**Research Model**

In this section, critical factors affecting the users' adoption of innovation is discussed.

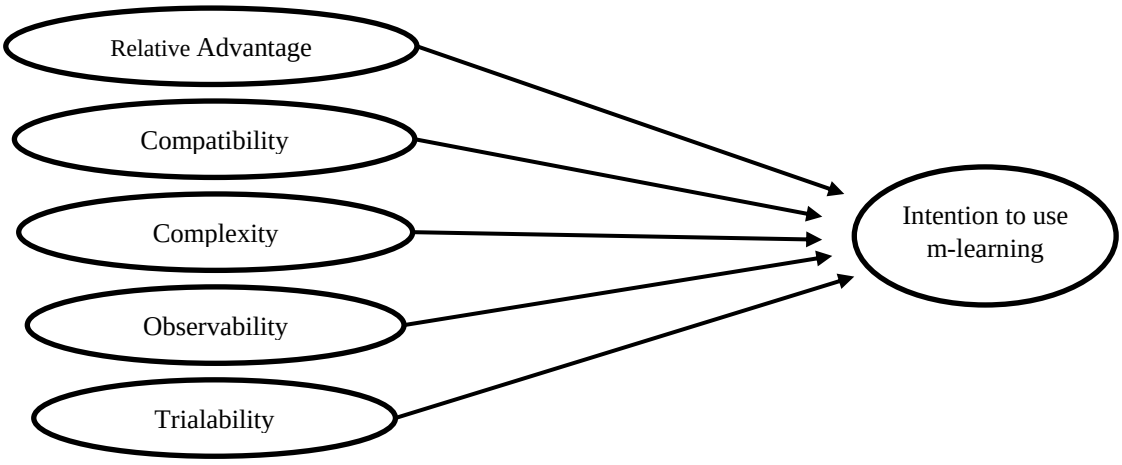


**Figure 1.** Research model

***Relative Advantage***

Relative advantage refers to the degree to which an innovation is perceived as providing more benefits than its predecessor (Moore & Benbasat, 1991). Prior researches suggest that when user perceives relative advantage or usefulness of a new technology over an old one, they tend to adopt it (McCloskey, 2006; Rogers, 2003). This feature of Roger's topology has been studied by various researchers in the context of mobile banking adoption (Lin, 2011; Al-Jabri and Sohail, 2012); e-learning & blended learning (Tshabalala, et al. 2014); electronic commerce (Seyal and Rahman, 2003; Ndayizigamiye and McArthur, 2014); Web-supported instructions (Soffer et al. 2010) and mobile learning (Mcconatha et al. 2008). Therefore, we hypothesize that:

*H1: Relative advantage is positively associated with the students' intentions to use m-learning.*

***Compatibility***

Clarke (2000) found ease of use to be one of the five significant factors that determined general use of wireless handheld devices. An individual might have a higher intention to adopt mobile learning if they think mobile learning is easy to operate. Again, Lu and Viehland (2008) found a support in their m-learning study in New Zealand. Thus, on that basis, we propose our second hypotheses:

*H2: Compatibility is positively associated with the students' intentions to use m-learning.*

***Complexity***

Cheung et al. (2000) defined complexity where an innovation could be considered relatively difficult to understand and use. They found that complexity influenced the adoption of Internet use. Chau and Hu (2001) and others had demonstrated that attitude towards using a technology was the significant determinant of behavioral intentions. A vast body of research had suggested that there was a strong support to ease the use of this new technology on its adoption (Luarn & Lin 2005; Wang et al. 2009). Chau and Hu (2001) also found that users were more likely to use new innovation if they had strong feelings of easiness with those innovations. Thus, it is hypothesized:

*H3: Complexity is negatively associated with the students' intentions to use m-learning.*

***Observability***

Rogers (2003) defined the observability as the degree to which the results of an innovation are viable to others. Role modeling (or peer observation) is the key motivational factor in the adoption and diffusion of technology (Parisot, 1997). Similar to relative advantage, compatibility, and trialability, observability also is positively correlated with the rate of adoption of an innovation. Al-Jabri and Sohail (2012) used this in the context of mobile banking and found that it was significant. Thus, it is hypothesized:

*H4: Observability is positively associated with the students' intentions to use m-learning.*

***Trialability***

According to Rogers (2003), trialability is the degree to which an innovation may be experimented with on a limited basis, where trialability is positively correlated with the rate of adoption. Therefore, more an innovation is tried, the faster its adoption. Potential adopters who were allowed to experiment with an innovation would feel more comfortable with it and were more likely to adopt it (Agarwal & Prasad, 1998; Tan & Teo, 2000). Thus, it is hypothesized:

*H5: Trialability is positively associated with the students' intentions to use m-learning.*

## METHODS

From the review of the literature and on the basis of the model developed that fulfilled the research objectives, the questionnaire was then modified and edited. On the basis of face and content validity, it was revised and refined before administrating the survey. The multidimensional instrument was developed in three parts to capture the information. The source of instrument was adapted from Moore & Benbasat (1991) and Davis (1989) and then it was modified to cater further the m-learning context.

From the review of literature, several quantitative research methodologies existed (e.g. survey, experimental, quasi- experimental) and were frequently used to test a theoretical underpinning (Creswell, 2003) especially when the respondents were asked to provide information about themselves for example about their attitudes, beliefs, demographics or past behaviors (Cozby, 2004). The techniques like step-wise sample size determination were used as suggested by (Simon & Burstein, 1985) in order to justify the sample size, i.e., not be less than 100. The sampling frame included all the students who owned 3Gs mobile phones, tablets or PDAs.

One hundred and fifty questionnaires were distributed to the students in School of Management. Out of them, 80 questionnaires were received. After closer examination, seventy-five were retained for the study. This made the response rate to 50% that would have been considered sufficient to draw logical conclusion. This was in line with the minimum recommended rate of 30% for survey research (Johnson and Owens, 2003).

## RESULTS AND FINDINGS

In order to get the reliability of the questionnaire, the coefficient of Cronbach's alpha (1951) was taken into account. Minimum Cronbach's alpha values were greater than 0.70 to indicate reliability of the instrument (Nunnally, 1978). During the initial screening of conducting reliability tests, some items were dropped because of low corrected-item total correlation which was less than 0.40, i.e., the cut-off value suggested (Hair et al., 1998). In addition, the Kaiser- Normalization as techniques of rotation was used to examine both the individual items and the relationship among them (Hair et al., 1998). Churchill (1979) had suggested that convergent and discriminant validities should be examined for construct validity. Therefore, convergent validity was assessed by examining composite reliability (CR) and average variance extracted (AVE) from the four constructs (Hair et al., 1998).

CR is then calculated by squaring the sum of loadings, and dividing it by the sum of squared loadings, plus the sum of the measurement error whereas, the AVE measures the variance captured by the indicators relative to measurement error. The CR values for all four constructs were within the suggested minimum of 0.70 (Hair et al., 1998). The average variance of 0.50 had been suggested to cater the need for further evidence for convergent validity (Fornell and Larcker, 1981) These AVE values could also be used to assess discriminant validity which occurred when the AVE exceed the square pair wise correlation between the construct (Espinoza, 1999).

To examine the common method variance, we conducted a Harman's single factor test (Podsakoff et al., 2003) by using SPSS factor analysis. The result has indicated that the largest variance explained by an individual factor is 45%. It might seem high but is still below 50% of the cut-out limit. The relationship of the students' various attributes of DOI with the dependent variable intention to use was investigated using Smart-PLS; multiple regression analysis. The Partial-least squares were used to test the hypothesized relationship among the variables in the model. This PLS is a second-generation multivariate technique that facilitates testing of the psychometric properties of the scales used to measure a variable, as well as the estimation of the parameters of the structural model i.e. the strength and direction of the relationship among the model variables (Fornell and Larcker, 1981; Lohmoller, 1981).

The PLS allows the researcher to test the relationship within the measures and the hypothesized relationships between the measures simultaneously (Lohmoller, 1989). Re-sampling procedure such as bootstrapping which produce t-statistic was used to assess the structural paths (Chin and Newsted, 1999). In addition, model's predictive power was assessed by using R2 value for the endogenous variables (Fornell and Larcker, 1981). The explanatory power of model indicates that 42% of the total variance towards adoption intention is explained showing the moderate parsimony of the model.

The study fulfills the objectives of this paper as to determine the level of usage of m-learning and to identify the factors that are significant in explaining the adoption of m-learning among students of a university in Sakarya. The objectives of this paper are to determine the level of usage of mobile learning and to identify the factors that the learners' intentions to adopt are of relative advantage, compatibility, complexity, observability, and trialability.

Previous studies have suggested that only the relative advantage, complexity, and compatibility are consistently related to innovation adoption (Ryu et al, 2009; Wu & Wang, 2005). Similar with the existing literature our results show that the relative advantage has remained the significant determinants of m-learning adoption. This further elaborates that learners still agree that any new IT/IS features should provide benefits when compared to other conventional technologies (that is equivalent to perceived useful component of TAM). These results have indicated that 80% of the students (mean = 3.84) ave understood that using m-learning platform for educational purpose have provided benefits such as accessibility, immediacy and portability as mentioned by Barker et al. (2005) and

Joo et al. (2014). The results therefore support all previous studies such as; Joo et al. 2014; Ndayizigamiya and MacArthur, 2014; Fu et al., 2007; Jebeile and Abeysekera, 2010 and Al-Jabri and Sohail, 2012.

Compatibility with university technological infrastructure and value system further strengthen the students' intention of m-learning adoption. This has been confirmed that subjective norms in TRA/TPB and compatibility with technology infrastructure and existing value system were significant predictors of various IS/IT adoption (Seyal & Rahman, 2003; Seyal, 2010; Seyal et al., 2012; Lu and Viehland, 2008). About 78% of the users (mean= 3.40) have shown concern about their compatibility issue which is very significant.

The complexity attribute remained insignificant contributor towards learners' intention to adopt m-learning. The negatively worded items were changed so the high mean value of (mean = 3.84) is in fact not high but indicated low value that further suggests that for the majority of the learners' complexity was not a big issue. Our results therefore do not support Joo et al. (2014) and Wang et al. (2009).

Both trialability and observability results support the previous studies (Sheng et al., 2011; Joo et al., 2014). 42% of the shared variance is in fact shows better predicting power than the contemporary model even better than the original TAM model that explained roughly 40% of the variance towards behavioral intention. Results also support Chau and Hu (2001) who stated that 42% of the variance was explained in intention to use.

## CONCLUSION

This preliminary study on students used of the m-learning was necessary because the m-learning in higher education institution is still at early stage. The results indicate that two of the five constructs of the original DOI are strong predictor of students' intentions on m-learning. We therefore, could use the results of the study for supporting research on developing m-learning technology for the students in future. The model as sufficient parsimony as determined by 42% of the shared variance toward m-learning was explained by the two significant predictors.

As in most researches using survey methodology, this study has its weaknesses. Several limitations of this study qualify the findings and suggest direction for future research. The study is limited to its small sample size and it model. The study is further based on single institution and caution should be taken to generalize the results of this study on this basis. By readdressing and expanding the study with extended items from TAM 2, TAM3 and/or UTAUT, will bring further insight that will definitely help to improve the study.

The study found relative advantage and compatibility from DOI contributed towards students' intention to use m-learning. This further suggests that there is a strong need for the university administration and other policy makers to be acquainted with the various benefits of m-learning in order to stimulate its adoption. Therefore, a step-wise approach as proposed by Ndayzigamiya and McArthur (2014) to start with simple m-learning application that provides relative advantage and compatibility with existing university infrastructure and then move gradually toward more complex m- learning applications and in this transition, all the stakeholders should be taken on board.

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# PERCEPTUAL INTERFACES FROM THE PERSPECTIVE OF HUMAN-COMPUTER INTERACTION AND ITS USE IN EDUCATION

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**ABSTRACT:** The human-computer interaction is a hot topic because of the considerable increase in the production and use of information and communication technologies. In this interaction context, new generation interaction styles have emerged by the constant advancements in the technology. One of these interaction styles is perceptual interfaces that contain different kinds of high level natural interaction. This interaction is based on natural human-human interaction style like gestures, touching and speaking. The purpose of this research is that to examine perceptual interfaces in the perspective of human-computer interaction and infer some results about how to use them in education and offer suggestions about it. In this study, interaction design of the perceptual interfaces was discussed according to the reviewed literature. Also, motion-based technologies, used in these interfaces, were presented and use of these technologies in the field of educational technologies was examined. It is considered that the results of the study can provide guidance to researchers and practitioners. There are many types of perceptual user interface interaction. Today, the most popular application area of the motion-based technology is Kinect technology. This technology includes a variety of perceptual interaction such as; image viewing, skeletal detection and monitoring system. Kinect technology is one of the most popular devices in the field of image processing technology that can detect movements and send these to computers. Kinect technology was developed by Microsoft to play digital games with Xbox console and it has been used in other areas as time goes by. Although this technology originally developed for digital games, it has often begun to be used in scientific researches by the capability of catching depth of an image. By considering that perceptual interfaces can provide natural interaction to individuals like in their social life, users can exhibit their skills without extreme cognitive load and they can learn easier via perceptual interfaces. In this context, it is envisaged that perceptual interfaces can support learning by providing ease of use and control.

**Key words:** Natural user interfaces, perceptual interfaces, motion based technologies, kinect technologies, educational technologies

## INTRODUCTION

We use many different products for various goals in daily life. Everything which exists with these products is in interaction with each other (Dix, Finlay, Abowd & Beale, 2004). Thus, the interaction of a product with human should be considered if its design is demanded to be used (Olson & Olson, 2003). Interaction is defined as the response from a case or affecting each other mutually (Dix, Finlay, Abowd & Beale, 2004). Number and variety of interaction between human and technological products increase as a result of rapid increase in the production and usage of information and communication technologies. The concept of human-computer interaction started to be a matter of many scientific researches on this generated new case. Cagiltay (2005) defines the interaction between human-computer as an interdisciplinary study field concerning in the interactive technologies' design, evaluation and application. One of fields that the interactive technologies are used within the scope of this definition is education. Stephanidis, Kouroumalis & Antona (2012) defend that the interaction needs to be considered within the sense of relation between "new media" and "educational technologies". These technologies require to be designed to meet users' needs (learners) in the easiest way (Norman & Draper, 1986) in order that new media usage in educational technologies contributes to learning environment.

The rising generation interaction styles which have occurred with the developing technologies in the field of human-computer interaction have got important role in the design of new media which will be used in educational technologies. Some of this rising generation interaction styles are; virtual reality, augmented reality, ubiquitous or pervasive interaction, tangible user interfaces, embodied interfaces, lightweight, tacit, passive, implicit or noncommand interaction, perceptual interfaces, affective computing, context-aware interfaces, ambient interfaces, wearable computing, sensing interfaces, eye-movement based interaction, speech or multi-modal interfaces, brain-computer interfaces. The focal point of this research is to comprise the useful of perceptual interfaces from these styles in the field of educational technologies.

**Perceptual Interfaces**

Sense is defined as the case that individual is aware of an object, quality or events which stimulate the individual with help of sense organs (Inceoglu, 2010; Morgan, 1984). Perception is defined as matching mental components with data from senses and being able to understand goings-on in an environment (Aral, 2000). Perceptual psychology defends that human's experiences consist as a result of senses' stimulation (Goldstein, 1989). Sense is classified by five senses as visual, dimensional, aural, olfactive, tactile (Caglayan, Korkmaz & Oktem, 2014). In another saying, perception can be defined as a case which occurs as a result of the interaction between individuals and living or nonliving assets around them. Accordingly, human may interact with computers in a similar way with their interaction between each other and physical world. Sociology and psychology sciences determined that human interacts with computer and other communication technologies with social and natural ways (Reeves & Nass, 1996). Additionally, human perceives the environment by sense organs for the human-human interaction and also human-computer interaction (Sharma, Pavlovic & Huang, 1998).

Perceptual interfaces are structures which provide opportunity to be interacted with user in more than one channel. While the user interacts only with writing or the help of mouse in traditional interfaces, interactions such as speaking, touching, mimics take place in perceptual interfaces additionally. Perceptual user interfaces which present high interaction and varieties were modelled in the base of natural interactions between human and human. For example, seeing, hearing, touching, speaking etc. (Turk & Robertson, 2000). Additionally, perceptual user interfaces require the integration of many technologies which perceive sound and speech, include graphics animation and visuals, perceive the sense of touching and provide feedback (Turk & Kolsch 2003; Geng, Strauss, Fleischmann, Elistratov & Kolesnik, 2003). In that vein, Turkoglu (2010) argues that actions which doing, hearing, seeing and speaking functions are simultaneously used make the learning more permanent.

The point to be considered was emphasized on how people's perceptual experiences work, how machineries would change and impair people's sense (Reeves & Nass, 2000). The process between people's acts and computers' perceiving these acts was showed at Table 1 (Geng et al., 2003; Sharma, Pavlovic & Huang, 1998). Additionally, Turk & Robertson (2000) stated that another goal of perceptual interfaces is to give opportunity to individuals to transfer their social skills by providing natural environment such as their social life without being exposed to extensive cognitive load.

**Table 1:** Modalities mapping between human action and computer sensing (Geng vd., 2003; Sharma, Pavlovic & Huang, 1998).

| **Human Action Modalities** | **Device** | **Computer Sensing Modalities** |
|---|---|---|
| Typing, Handwriting, Pushing and Clicking, Gloved-Hand Gestures | Keyboard, Tablet, Mouse, Glove, etc. | Position/Motion |
| Speaking | Microphone, Voice Recognition and Synthesis | Audio |
| Body Movement<br>Head Movement<br>Free hand gestures<br>Facial expression | Camera, Vision-Based Tracking & Recognition | Video |
| Eye Movement | Eye-Tracking System | Video |
| Hand Pressure | Haptic Device | Tactile/Force |
| Brain-activity | EEG | Neural |

**Usage Areas of Perceptual Interfaces**

The literature related to the usage fields of perceptual interfaces is reviewed, it is seen that this interaction style is used in many fields Geng et al. (2003) indicate on their research that perceptual interfaces give opportunity to people to shop virtually from a shopping center as they do not shop physically. In this study, it was reviewed how people would shop with the use of a device like a treadmill that they would control with 3-dimensional navigations and gestures.

Students' motivation is one of the most important factors in the learning process. Students' motivation is measured by surveys in traditional methods, but these kinds of measurements are not proper in game-based learning as the concentration of person who plays game is affected negatively. The study which was done by Ghergulescu & Muntean (2014) aimed to measure students' motivation with a perceptive-based measurement method with the help of EEG without disturbing player. This study which was conducted by 48 persons that their ages change at the range of 18-55 was applied to all of them and took 45 minutes. Consequently, it revealed that the application of survey was not efficient to measure users' motivation but a perceptive-based measurement method measured their motivation better (Ghergulescu & Muntean, 2014).

As reading includes complex cognitive processes, it is difficult to determine on students' development with observations. E-books are indicated as a way to explanations students' reading difficulties and weaknesses. It is aimed that students' reading behaviors are observed with the help of touch-operated interfaces and e-books. 3 phases were followed in a research which was done for it; 1) the analysis of real classroom conditions, 2) the design and application of system, 3) the evaluation of system's availability and functionality. Students' reading process were recorded in the base of an algorithm with the help of a touch screen and web camera in this study which was done with 15 persons. Consequently, reading process which its determination was difficult by being observed was determined in an easier way with the help of this record (Huang, Hsu, Su & Liu, 2014).

In another study, which aimed to measure cognitive load from mimics, cases of 20 persons to make mental mathematical processes were measured with a camera put on computers' top and some devices (ECG, SC, BIOPAC, MP1502 & RESP) put in participants. Results show that it was considerably succeeded to determine on factors of using face modelling causing cognitive load while cognitive load was measured (Hussain, Calvo & Chen, 2014).

In another research, which aimed to measure effects of different methods with their matching as visual/tactile, visual/aural, visual/aural/tactile, total 26 university students that 12 of them are females and 14 of them are males were studied. Trainings were applied to students in 3-dimensional areas that consist of three different combination in double groups, that (1) are visual and tactile which users see and feel interface, (2) they see and hear interface, (3) users see, touch, hear interface. In these areas; it was asked from them to position cubes in cells on a screen. The application was recorded in a video in order to evaluate the process and a survey was used to users. Results indicated that interfaces which visual/aural/tactile factors were used together increased the students' awareness on environment and also provided that they felt themselves much more in safe (Moll, Pysander, Eklundh & Hellström, 2013).

In similar way, in another study which aimed to determine on users' psychological and so sense case with the help of visual and aural stimulus, total 24 university students whose ages change in 20-30 years were studied. Users indications such as psychological signals, mimics, breathing were examined with the help of 24 visual and 24 aural factors which their validity was proved (IAPS visual, IADS aural) as they were recorded by method with the aim to measure sense such as electromyogram and electroencephalography. Those records were done as the system perceived image and sound. Results indicated that aural stimulus was more effective than visual stimulus on perceptual interfaces (Zhou, Qu, Jiao & Helander, 2014).

Bickmor & Cassell (2004) developed the embodied conversation agents (ECAs), using robots and imaginary avatars in order to make a face-to-face communication. Users are asked to read the short letter and to reply 3 questions related to the letter that they read, in each phase of 3-phase study that Morency, Sidner, Lee & Darrell (2007) developed it using these agents. Each of texts and questions presented to users differ in each phases. All of participants have got the skill to use mouse and keyboard in the study that 19 persons attended but none of them have used a technology which would be controlled by gestures. While 12 of participants attended in first two phases, 7 of them attended in each of 3 phases. Each of phases took nearly 2-3 minutes. At the end of each phase, participants were asked to reply question to evaluate keyboard, mouse and the system that they used their gestures. 2 questions in five-point likert type were asked and the natural usage and effectiveness of these three applications were tried to be measured. Participants were asked to choose pdf document with the help of mouse or keyboard in the first phase of the experiment, to choose it with the use of gestures in the second phase and to prefer one of the system that they used mouse, keyboard and their gestures in the third phase. As a result of the research, it was determined that the technology which would be controlled by gestures was more effective.

As it was mentioned on the relevant literature, there are many perceptual interface interaction varieties. Today, the most popular application field is Kinect technology. This technology includes varieties of perceptual interaction such as monitor image, perceiving and monitoring system for frame.

**Kinect Technology**

Kinect which is one of the most popular devices at the field of image technology and which would send people's gestures to computers after perceiving them was developed by Microsoft in order that games are played by Xbox game console and its usage has become spread in other field in time. Even though this technology which includes perceptual interaction was firstly produced in the purpose of game, it started to be used often in scientific studies as depth image would be taken.

While left eye of Kinect (Fig. 1) which has got a mike on it, a motor mechanism to provide gesture and three eyes make laser projection, infrared sensor on right informs the distance of each point as calculating arrival-going period of these rays. In light of this data, the software in Kinect sends data to Xbox or computer after calculating the structure of frame (Colvin, Babcock, Forrest, Stuart, Tonnemacher & Wang, 2011). The eye in the middle of Kinect is a 30 FPS (Frame Per Second) VGA (Video Graphics Array) camera with 640 x 480 resolution. The image which is gotten is sent to the application as photos for 30 times in a second (Stowers & Hayes, 2011). Moreover, Kinect sends data that it gets with the use of sensors to the natural interface's library of user as sound, image and depth, and sends to applications after interpreting them here (Colak, Yuksel, Sunguray & Gumus, 2013).

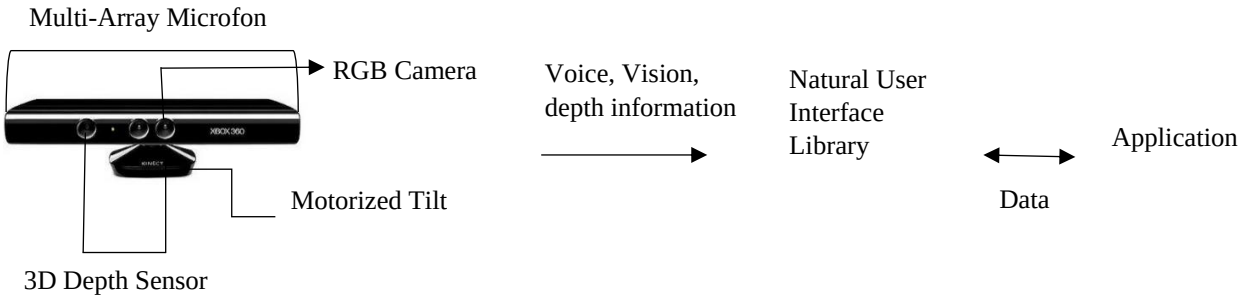


**Figure 1.** Kinect technology and data flow direction (Colak, Yuksel, Sunguray ve Gumus, 2013)

Another property of Kinect technology is the perceiving and monitoring system for frame (Fig. 2). Infrared camera spreads rays of infrared into the area as the command of gesture perception is given and so 20 different starting points in people's body are perceived and monitored (Sidik, Sunar, İsmail & Mokhtar, 2011; Ikemura & Fujiyoshi, 2011). If the act which is done is an act registered in ROM's of Kinect, a warning code is sent to computer by the system. If it is not available between gesture-defined gestures which are done, Kinect keeps the system for waiting (Tong, Zhou, Pan & Yan, 2012).

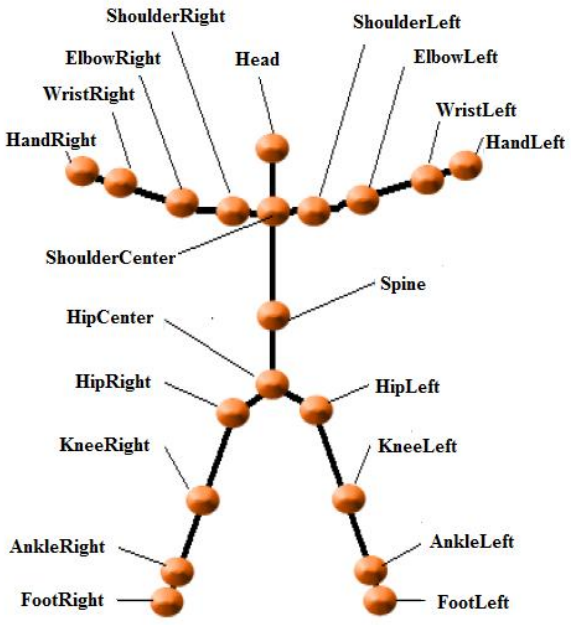


**Figure 2.** Microsoft KinectTM joint points (Colak, Yuksel, Sunguray & Gumuş, 2013)

**Usage Areas of Kinect Technology**

On a study, which was done to measure the console of Microsoft giving opportunity with hand and arm gestures, Kinect technology and mouse's usability; 10 persons used mouse and 10 persons Kinect technology having motion-based interaction opportunity as using MetricSPlat which is software that information is visualized. It was concluded that Kinect technology is more effective (to provide a natural interaction) in measurements which are done by the usability test (Libardi, Traina & Rodrigues, 2014).

Chang, Chen & Huang (2011) stated that the learning environments which are done with the use of Kinect technology are helpful to get daily life skills for students and to transfer them to real life. Tenekeci & Gumuscu (2016) made two-phased study with the application which was done on the use of Latin characters used in Turkish for first reading and writing training. A screen was prepared in order to promote letter in the first phase of application. If the frame information belonging to person using the application comes on the letter that it demands as being interpreted by the program and waits sufficiently, it is provided that this letter is sent to the used aurally. The child wants to listen to whichever letter's name again, it is necessary to come on that letter and then to wait on the definite icon for a definite period. On the second phase, a screen which the child learning letters would test himself was developed. On this screen, names of letters are randomly listened to the user and the student is asked to come on the letter's icon that he listens to it and then to stop in a definite period. If the student answers correctly, new letter is asked after he is congratulated, if he chosen incorrect one, he is asked to try again as he is said that his selection is incorrect. In the next phase, the application based on the procedure to wait or not to wait for one of hands on any letter in a definite period is coded as the frame data from Kinect is interpreted.

Some applications such as calculator, music orchestra settlement, the settlement of organs in people's body and management of PowerPoint presentation that the user would use all of applications as running without having any contact with the use of a training application which was developed in Microsoft Visual Studio platform and with the use of Kinect technology were developed. While a presentation is provided to work, and be managed in an automatic way by sound as properties of sound are added to open the presentation in procedures of presentation, the same procedures were provided to be controlled in a contact-free way also. As it was aimed that users learn with much more doing in the training application, Kinect Software Development Kit (SDK) which its use was tried to be kept simply was used (Colak, Yuksel, Sunguray & Gumus, 2013).

Hsu (2011) considered Kinect in terms of two points. First of them is that Kinect will increase students' motivation as making courses more enjoyable and will create a stimulus effect on the student in the case that a course plan and courses' interaction are designed carefully. The second one is that Kinect would substitute of a learning tool that students would create their own information as it is used like an educational software in a way that the educational softwares contribute to students to create their own information. Moreover, Kinect which increases the interaction and participation in the classroom supports that teachers make discussion in the classroom by using multimedia and also it provides that the skills of interaction increase (Hsu, 2011).

## CONCLUSION AND DISCUSSION

When it is considered that people have interaction with computer and other communication technologies and social and natural ways, people have interacted with computers in a similar way that they interact with each other and physical world (Reeves & Nass, 1996). When it is considered that perceptual interfaces provide a natural interaction for individuals like their social life, it is thought that users would exhibit their skills without having extensive cognitive load and they would learn in an easier way thanks to perceptual interfaces (Turk & Robertson, 2000). In this sense, it is estimated that the use of perceptual interface provides the easy to use and control, and would support the learning. For example, it can be helped to pre-school children who try to get daily life skills newly about preparing a learning environment, gaining daily life skills and transferring them into real life as using Kinect technology. Additionally, when it is thought that pre-school children would learn better in learning by doing activities, the learning environment would be enriched as Kinect technology which its use is tried to be kept in a quite simple way is used.

The interaction between human-product should be definitely considered in order to provide the use of perceptual interfaces and easy for its control (Olson & Olson, 2003) and it should be paid attention on how perceptual experiences work, how machineries would change people's perception and would improve them (Reeves & Nass, 2000). There are seen some advantages and disadvantages related to the use in education.

More effective perceptual user would be designed as goals that Preece, Rogers & Sharp (2002) stated them while telling the topic "User-Interface Design and Usability" are considered, it can be provided with the designed

perceptual interface that the interaction between student or teacher is increased (to take the product- user interaction to the optimum level), so that the product is easily used (to develop usable products) and lastly the designed perceptual interface meets users' needs as giving natural interfaces (to meet the product users' needs and experiences). For example, Kinect technology can raise the interaction and participation in class as a support for teacher to take discussion in class as using multimedia. Moreover, it can be provided that interaction skills such as student-student, teacher-student, teacher-technology and student-technology increase. The suitability of this product's design can be interpreted as usability of this product and in what extend it interacts with user. While it designs perceptual interface for education, the points such that the use of designed interface is easily learned by user (learnability), it provides benefit for user and reinforces the learning (efficiency), users would remember easily the use of perceptual interface (memorability), the user estimates faults that they are possible to do as using perceptual interfaces (how severe are errors) and the user is satisfied with the use of perceptual interface during the training (satisfaction) should be paid attention (Nielsen, 1993). Systems' design goal is to provide easy and effective use for users. So, interface designs require to meet users' needs in the easiest way (Norman & Draper, 1986).

It is at the main of perceptual interfaces' advantages that it provides opportunity for users to have interaction with user in more than one channel (Turk & Robertson, 2000). Moreover, it is considered that individuals understand complex cases in easier way when they use their three-dimensioned motor skills (Hsu, 2011). In this sense, it is considered that the use of perceptual interface provides the usage and control easiness for individuals and it will support the learning. While the user has interacted only with writing and the help of mouse in the traditional interfaces interactions such as speaking, touching, mimics take place in perceptual interfaces additionally. Turkoglu (2010) argues that actions which doing, hearing, touching, seeing and speaking functions are simultaneously used are more permanent for users. Similarly, as methods which would be controlled by gestures provide natural interaction, it was determined that it is more effective than methods that tools such as mouse and keyboard are used (Libardi, Traina & Rodrigues, 2014; Tong, Zhou, Pan, & Yan, 2012). For example, words which are demanded to be taught to the user can be previously identified to Kinect technology as a perceptual interface is designed for individuals who want to take a sign language training with the distance education. When it is considered that gestures and mimics have got very big importance in sign language, users should be informed as it is determined on whether individuals pronounce or don't pronounce correctly words in sign language with the help of Kinect.

Waibel (2006) mentions that perceptual interfaces are smart tool to make interaction easy further to that they would not be seen only as data input tools only substituting keyboard. He states that this advantage provides that interfaces in daily applications are proactive, social and much more in the work but two problems are seen in this scope. First of these problems is comparative linguistic communication which is supported by machineries and the second one is computers which provide services taking base the observed and perceived needs rather than people's observable direct interactions for people's interaction cycle. For example; Kinect technology would be used on whether individuals pronounce words correctly in foreign language learning and to teach them if they pronounce them incorrectly so how to pronounce them correctly. Even the same function seems to be done on a computer program at first look, more detailed training and evaluation can be done as Kinect technology has got a property to perceive gestures and mimics.

As perceptual interfaces, present natural environments for individuals such as their social life (Turk & Robertson, 2000), individuals would gain social skills in easier way and they would easily transfer their information without having extensive cognitive load. In this sense, using face modelling can provide easiness to determine on factors causing cognitive load while cognitive load is measured (Hussain, Calvo & Chen, 2014). Similarly, students' development can be determined in easier way with the help of touch-operated interfaces in the cases which include complex cognitive processes such as reading (Huang, Hsu, Su & Liu, 2014). For example, e-books are showed as a way to explain students' reading difficulties and weaknesses. It is aimed to observe students' reading behaviors with the help of touch-operated interfaces and e-books.

As the survey applications are inefficient to make users' motivation measurement (Ghergulescu & Muntean, 2014), method which would do measurements automatically after perceiving the user's gestures can be preferred for a healthier measurement. Furthermore, perceptual interfaces provide opportunity for individuals to necessary activities virtually in an area that they are not available physically. For example; a person can go to a shop virtually and shop as acting like being in a real market without going to a market physically (Geng et al., 2003). The more important is that it can be provided for individuals to have got an experience very close to real one in medical and piloting trainings which their error margin is 0%. So, a medical student has got chance to experience possible cases previously in the closest way to real one as having a heart operation. This case is valid for piloting trainings also.

Moreover, Pentland (1999) mentions that many objects which we use in our daily life such as table, car and shoes cannot have interaction sufficiently with individuals, so they are restricted to be useful and meet their needs. Thus, it is emphasized that smart classes would be designed without depending on devices such as keyboard and mouse as technologies to follow individuals' gestures and perceive their face, mimics and expressions. According to principles of accessibility, it is necessary that the training gives opportunity to different learning environments and supports the individualized training. The perceptual interfaces can be used to make these environments (Burzagli, Emiliani & Grazian, 2004). Similarly, the learning environment was described as a smart environment which was reconstructed and integrated into other smart environments, in the scenario named with "Annette and Salomon-environments for social learning" that Ducatel, Bogdanowicz, Scapolo, Leijten & Burgelman (2001) prepared it. In this sense, many new technologies were developed in the event that the learning environment is provided to be integrated in other smart environments. Perceptual interfaces are accepted one of these technologies to provide this integration and make smart classes. For example, an experiment which has danger to be done in laboratory area can be done in the classroom with the help of Kinect technology as students are taken to the board. So, it will be provided that students construct their own information and also students' motivation will increase because the stimulus effect will raise in the student.

Perceptual user interfaces require the use of technologies together which perceive speaking and touch sense, provide feedback and include graphics animation and visuals (Turk & Kölsch 2003; Geng et al., 2003). Additionally, perceptual user interfaces which would reach wider target groups and would reach sense organs in order to raise usability should be developed in consideration that sense is classified by five senses as visual, dimensional, aural, olfactive and tactile (Caglayan, Korkmaz & Oktem, 2014). Even if it is included in the literature that the use of visual/aural/tactile factors together increases the students' awareness on environment and provides that they feel themselves in safe (Moll, Pysander, Eklundh & Hellström, 2013), it should be paid attention that a cognitive load is not caused in the user as using unnecessary many factors together.

One of the restrictions in Kinect technology is that it would perceive only 20 different parts in people. In this case, if the gesture that the user makes is not a registered one, it is not perceived by the system (Tong, Zhou, Pan & Yan, 2012; Suzen & Tasdelen, 2013). The raising generation interaction styles are used in many experiment environments with its structure. When this interaction styles go out if experimental environments and then takes in real applications, there would be problems in the integration, operability and compliance between objects and devices. Moreover, security and privacy topics come up as environment and devices more than one have got contact with each other. Additionally, as these environments need an environment with constant internet (Wireless or Mobile access), it increases the cost of this technology (Stephanidis, Kouroumalis & Antona, 2012). Furthermore, there are other restrictions; a wide application area is necessary in classroom during the use of Kinect and programs which would be used with Kinect technology are not efficient (Hsu, 2011).

When results of the relevant researches are considered, it can be said that technologies which provide the user to have one-to-one interaction with the system have got much more effect on learning (Preece, Rogers & Sharp, 2002). Another result is to be concluded that; as we increase the integration with user so the technology will provide benefit for the user in that scale (Preece, Rogers & Sharp, 2002). Moreover, it is stated that multiple-choice surveys are not sufficient always to measure the usability of a designed system, perceptual measurements which will be done without interrupting the interaction process of users will be more beneficial when the interaction is especially wanted to be measured (Ghergulescu & Muntean, 2014).

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# BLENDED ACHIEVEMENT AT TRANSNATIONAL SCHOOLS AS COLLABORATIVE LEARNING COMMUNITIES- TOWARD A SYSTEMIC ASSESSMENT METHODOLOGY

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**ABSTRACT:** Education in public and private schools and higher education institutions is experiencing by beginning of the 21st century accelerating methodical changes from massive residential to online, blended, and wireless schooling. Assessment on another hand, while is seen the backbone of educational systems and the steering mechanism of classroom education, is generally lacking the practice of diagnostic needs and formative assessments. Blended schooling (BS) needs generally a compatible systemic approach for delivering curricula, instruction and learning in more rational focusing manners to mentor students towards achievement ends. The systemic assessment methodology in this article for measuring blended achievement in transnational schools as collaborative learning communities is aimed to serve above ultimate reforming purposes.

**Key words:** Blended assessment; collaborative learning communities; transnational schools.

## INTRODUCTION

Assessment is the grit of education that steers and develops learning and instructional tasks to their required goals. Schooling without well systemized and thoughtfully designed approach coupled with enabled assessment will turn into personal corrupted and aimless business, lacking the basic standards of validity and reliability to which any human endeavor including education should comply.

Ronan (2015) confirmed that "assessments are the key component of education systems and play a critical role in a student's learning journey. By measuring student achievement and skill mastery, assessments help students learn, teachers improve instruction, administrators decide how to allocate resources, and policymakers evaluate the efficacy of education programs". For needs and formative assessments, as observed, are rarely practiced in the education of Developing Countries. In addition, they are randomly applied in western education, and links between both and summative evaluation are missing (Maddalena 2009).

The biggest challenges facing the success of emerging assessment approaches of schooling whether blended, online or wireless are in building the culture of inter-related systemic diagnostic, formative and summative assessments. In fact, more educators and school leaders are calling for abandoning state summative massive unified exams for the sake of more practice of diagnostic and formative assessments (Williams2014) and for applying assessment as "an integral part of the learning and teaching cycle" (University of Tasmania 2011).

### Blended Assessment Terminologies

#### *Blended Learning Achievement*

Blended learning occurs when face-to-face class activities “integrate with online alternatives in a planned, pedagogically valuable manner"(Teach Thought Staff 2015) by means of in-class learning stations, flipped / connected classrooms, online study carrels, school blended library and connected computer or resource centers.

#### *Blended Assessment*

Blended assessment (BA) is a "combination of a variety of direct and online assessment modes, such as paper and pencil tasks, online tasks, peer-assessment, and self-assessment” (O’Loughlin 2007). However, BA is conducted usually in individual and small group settings. But when final assessments deem necessary, assessment could be held in proctored exam halls, as providing online facilities at this stage seems impractical.

#### *Transnational Schools*

Transnational Schools (American Heritage® Dictionary 2011) are institutions which extend educational missions and practices beyond their national boundaries, thus involving several nations and nationalities in achieving stated goals.

***Collaborative School Learning Communities (CSLCs)***

CSLCs "are comprised of people who sense themselves connected to each other and to the world of education, where they are continually learning how to learn together". The working culture of CSLCs reduces human isolation, increases staff capacity, provides a caring productive environment, and promotes increased quality of learning achievement (SEDLs 1994).

CSLCs could operate in blended local homogeneous and foreign groups as: students with students, teachers with students, administrators with teachers, families with teachers, support services with teachers, experts with students. transnational students with local students and so forth. The means by which these CSLCs could professionally communicate are: online groups, blended groups, video conferencing, texting, online chatting, emailing, mobile and tablet interactions and meetings, laptop conferencing, Skype, classroom blended discussions, social media, school closed circuits and school sites.

***Systemic Assessment Methodology (SAM)***

SAM is a product of art and science of developing a measure and evaluation scheme for blended or online learning in accord with the principles of rational, valid and reliable criteria and mechanisms of the system approach. This SAM, when properly applied, will generate efficacy and effectiveness data for judging the quality of investigated learning achievement tasks.

**Structure and Use of the Systemic Assessment Methodology (SAM)**

New schooling and learning require new methodologies of educational assessment. SAM is a contribution in this direction (Figure1).

***Operational Structure of (SAM)***

The working components of SAM are organized into three interrelated elements which compose any educational system: inputs, processes and outputs (Figure 1).

SAM inputs

The main mandatory inputs considered in blended SAF are (Figure1):

Students who are self-learners of all ages and the backbone of Learner- Centered Paradigm

The curriculum. it is simply the academic message (content) of blended and online learnings

Schooling services. They are briefly of the following categories.

Human Services e.g.: Resource teachers, Educational aides, Psychologists, Student Counselors, Technicians, Assessment personnel, Maintenance Services, Managing Services and Financial staff

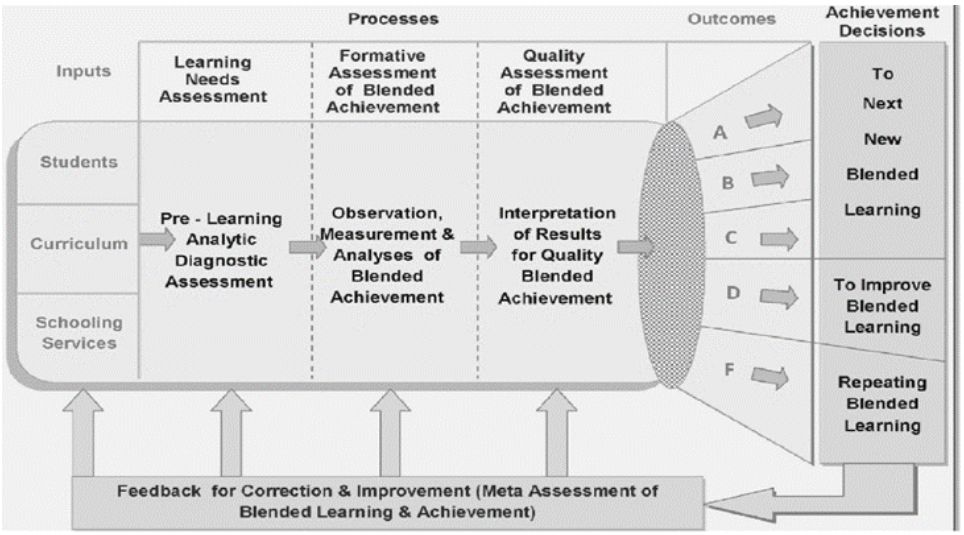


**Figure 1.** A Systemic Methodology for Assessment of Blended Learning Achievement

Blended Schooling Facilities: e.g.: Connected classrooms, computer stations, tutorial centers or areas, study carrels, learning clinics or learning diagnosing laboratory, seminar and discussion classrooms, learning resource

centers or rooms, and blended library. Blended Schooling Equipment, e.g.: Internet lines, Laptops, mobiles, Tablets, school audio and video circuits, and more others.

***SAM Blended Assessment Processes***

Assessment processes within SAM are operational tasks that are sequentially maintained by any psychometric specialist to reach the required appraising decisions concerning the quality of blended learning achievements. The ultimate assessment principle of SAM is the organic interweaving relationship among the three major components of blended assessment: diagnostic needs, formative and summative assessments. This principle specifically means that needs assessment will be inputs for the formative which in turn will be the inputs for summative assessments. Brief words concerning processes assessment follow (Figure1):

***Learning Needs Assessment***

This element concerns itself with diagnosing and analyzing students pre-learning backgrounds including previous knowledge. It is the most crucial mechanism within SAM for specifying the intended achievements that will result from blended learning contexts.

Conducting well planned needs assessments can help learners and teachers develop more engaging learning programs, adapt to change for more quality of learners' experience (knowledge transfer company. 2013). Debra Gordon (2015) added that the worst thing you can do is to develop a needs assessment based on your own thoughts and speculations without taking a critical look at the realities of students and schooling.

This Writer commends above Gordon's statement by assuring that without quality needs assessment, there will be no possibility to pinpoint the pure achievement gains in lieu of past acquisitions and plagiarism, commercially bought assignments or other illegal procedures. Any evaluative decision concerning learning achievements without firstly performing needs assessment will be totally subjective, misleading and worthless hunch.

***Formative Assessment (FA)***

This is an on-going task aims at steering and building learning toward achievement ends. FA provides constant performance feedback for students and teachers to improve learning and teaching.
FA however is embedded in SAM in three types:

- Formative Statistical Assessment by observation of learning and teaching, and the treatment of blended achievement data by appropriate measurement, analysis techniques and feedbacks.
- Formative quality assessment of blended achievement by Interpretation of achievement results.
- Meta formative feedback assessment) MFFA) which traces back the efficiency of all factors and processes embedded in SAM for correction and improvement.

***SAM Blended Assessment of Outcomes***
SAM outcomes are embodied in students' final achieved scores, values, and skills of studied courses. These outcomes are acquired by "summative assessment (SA)". Thus, the specific function of SA is to measure the final achievement of students at the end of an instruction, a course, a midterm, or at the end of school year. The SA decisions are made against specific norm or criterion-referenced- standards or benchmarks.

**Presage Procedures for SAF Successful Integration in Schools and Higher Education Institutions**

Successful integration of SAM in schools and higher education institutions is based upon the use of a **variety** of procedures, most important of them are:

***Mobile and Internet Technologies (MITs)***

Promising trends in mobile and internet blended learning (Fuhrman. 2015) range from 3D touch and electronic reality to wearables and the Internet of Things (IoT).

With Internet of Things (IoT), huge data is transmitted "from us, and to us" in real time. For education, that data stream will change the classroom and how we teach and learn. Using mobile devices and classroom applications, the IoT can provide instant records of students' readings, attendance and even the location of students who are supposed to be in class."

***Techniques for Assessing Blended Learning Achievement in SAM***

There are several techniques available for the assessment of blended and online learning. Examples of these are: self-tests, timed exams and quizzes, literature reviews, blended portfolios, online discussions, synchronous chatting, asynchronous threaded discussion groups, one-minute papers, e-mailing, course summary reports, individual and collaborative projects / simulations / case studies (Lorna 2012; Nari Kim 2008). However, brief illustrations of three basic techniques follow.

***Micro Blended Learning Achievement Units in SAM***

When segmenting learning assignments are into finite intakes, micro learning achievement units are materialized. This technique, in the era of digital information, self- learning approaches and student-centered paradigm, enables least ability students to achieve the required learning and self-assess their achievements. The learning and assessment merits of the micro educational or behavioral units and the high percentages of successful learners had motivated Fred Keller to coin the term: 'Good-bye, teacher' (Grovo HQ 2014; Keller 1968).

***Clinical Prescriptive Method in Blended Learning Achievement and Assessment (CPM)***

The CPM (Hamdan 2015) is a general operational methodology presented for blended schooling. It combines the principles and procedures of both the clinical practice of medicine and psychology and educational sciences of planning, learning, teaching, counseling, guiding, supervising, management, evaluating, curriculum, media technologies, and support services. The CPM is a diagnostic, scientific and problem solving mechanism for fulfilling students' needs through blended learning and assessment.

***Differentiated Students' Grade Contracts for Blended Achievement in SAM***

Time has come for school systems living the Global Digital Age and Learner- Centered- Paradigm where individual students are looked upon the "center of educational universe", to abandon the obsolete "whole sale schooling" massive / large group myth which caused societal huge losses in forms of student dropouts, failed courses, underachievers, wasted gifted and superiors' talents, wide spread plagiarism, low quality professionals and mediocre institutional and state leaderships.

This Author proposes accordingly advising individual students to progress learning through three flexible successive achievement levels:

- *literate learners* in the subject matter with C grade and marks 50-70/ 100.
- *Professional learners* of the subject matter with B grade and mark 71-90 / 100. The graduates of this category will be specialists in their fields such as teachers, engineers, pharmacists, technicians and so forth.
- *Future pioneers- scientists*, thinkers, inventors or gifted in the subject matter area usually with "A " grade and marks 91/100. Students of this category are required to study at least 50% more of required subject and assignments.

Individual students can advance throughout this trio-learning achievement methodology individually and /or small groups according to their self- paced and study topics. Students can start at any achievement level they feel confident to pursue, or simply begin with stream C and advance to B and A, as their personal, social and environmental conditions could help. And if one student fails at specific achievement assessment level, he or she will be assigned working on the lower grade.

***Assessment Grading Formulas for Quality Blended Achievement***

***Normative Assessment formulas:***

- **At schools** (formatives[1]: formatives first term; **n**: number of assessment)

* Annual system: ∑ (term1formatives[1]/ n + summative midterm1) + ∑ (term 2 formatives / n + summative at second term) = average = Grade
* Credit System: ∑ (formatives/ n + summative exam) / 2 = The Grade

- **At Higher Education**:

* (∑ (formatives/n + summative) /2) = The Grade

***Quality assessment formulas:***

- **At School**

* ∑ (term1formatives / n + summative mid term1) + ∑ (term2formatives/ n + summative of 2nd term) - (∑Average of Pre-blended achievements + ∑ Average of plagiarisms) = net value average = quality grade
* Credit System: (∑formatives/ n + summative exam/ 2) - (∑Pre-blended achievements/ n + ∑ Average of plagiarisms) = net value average = The quality score = The Grade

- **At Higher Education**:

(∑ (formatives/ n + summative exam)/ 2) - (∑Average of Pre-blended achievements + ∑ Average of plagiarisms) = net value average = quality grade

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# TEACHING ALGORITHMS BY EDUCATIONAL DIGITAL GAME PROGRAMMING

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**ABSTRACT:** The researches conducted by scientific community shows that student spare more time on games than activities like reading books, watching television. The popularity of computer games, which caused huge addiction on people since the day they were introduced, is increasing day by day. Educational computer games are developed in order to create a better teaching environment by benefiting from people's interest in computer games. Through educational computer games, students have the opportunity to have fun while learning. Researches prove that learning through educational computer games becomes more persistent on students. In addition, students can learn complex and hard to learn concepts in an easier way. The history of computer games begins from 1960s. Formerly the games used to be composed of simple screen images, they are now have gained 3 dimensional and more realistic display. Educators began to consider computer games as a tool that can be used in education, after their achievements in 1980 and 1990s (Mayer et al., 1999). As a result of these studies, concepts as Computer Aided Education (CAE), Game Based Learning (GBL), and Digital Game Based Learning (DGBL) have emerged. Software/Algorithm development courses are fundamental courses for computer science related departments. Besides, among these courses, students usually consider issues as decision-control structures and loop structures rather hard to learn. An educational computer game is designed in order to teach students these subjects with the help of computer aided interactive digital games. Kodu Game Lab, a commonly used application in the market, is used to design the game. In the game, it is aimed that students to learn the topic in a persistent and entertaining way with the use of three-dimensional graphics.

**Key words:** Digital game based learning, game programming, kodu game lab

## INTRODUCTION

Use of technology also became widespread in parallel with the rapid advancements in technology. There have been some changes in our lifestyle due to widespread technology. The expectation of society from individuals is also altered due these changes. Sınce one of the objectives of education is to train individuals with respect to society's expectations, it is now mandatory to train students that are compatible to information age (Kurbanoğlu and Akkoyunlu, 2003).

Talking about technology, the first technological product comes to our mind is computers. Computers are now usable in all fields due to advancing technology. At home, at school, at work, at grocery stores, shortly in every field and place that occurs to us, computers are used effectively.

Use of computers for education and teaching is named as computer aided education (CAE) in general. One of the sub branch of computer aided learning is educational computer games. Computer games composes the infrastructure of educational computer games. Computer games emerged with the diffuse of computers and became an indispensable aspect of our lives by getting popular in time. Educators began to consider computer games as a tool that can be used in education, after their achievements in 1980 and 1990s (Mayer et al., 1999).

Considering the developments in computer technologies and games, students interest in computer games and computers becoming a part of our daily lives; the use of computer games in education became a subject that should be emphasized on and utilized. Wıth the studies on this direction, the dullness of education performed through traditional methods will be overcome and education process will be joyous for students and a more persistent learning will be achieved (Tüzün and Bayırtepe, 2007).

## Computer Games

### *What is a Computer Game?*

In simple, computer games are a kind of software that are used via computers and played for entertainment purposes. Computer games may be defined through various technical terms. The most fundamental of these definitions is the definition goes as; computer game is an electronic interaction process where player sends electronic commands through user interface in order to get visual responses through a screen (Smed and Hokenen, 2003).

### *What is Digital Game Based Learning?*

The use of electronic devices such as computers, tablet computers, smart devices in the education and training process that allows students to recognize their insufficiencies and performance, get control of their learning through feedbacks; be more involved in courses with the help of graphics, sounds, animations and images by means of interaction may be shortly defined as Digital Game Based Learning.

### *History of Computer Games*

History of computer games goes back to 1960s. Computer games made a great progress since those dates to this date and now became an indispensable aspect of our day. Originally the game used to be composed of a simple screen image, it now converted to three dimensional (3D) more realistic structure.

### *History of Computer Games in The World*

When mentioning computers games, the first name appears in minds is William Higinbotham. William Higinbotham formed the basis of computer games by developing a simple tennis simulation in 1960. Later in 1961, Steve Russell, Martin Graetz and Alan Kotok developed another game. This game is Spacewar, a space war game having two players option and a feature that allows players to launch torpedoes.

**Figure 1.** An Image from spacewar game

In 1970, Computer Space game is launched to the market by Bushnell. Busnell transformed the game into a console application what works with token by adding a few features (Uysal, 2005).

**Figure 2.** Computer space game console

In 1975, with collaboration of Aclorn and Bushnell a brand-new step is taken in gaming world with the development of Home Pong which is a different version of pong game, a game which can be set up on televisions by a connection through antenna input.


**Figure 3.** Home pong game console

In 1980 a new era in computer world is created with the launch of Pacman by Japanese gaming company Namco. Users completely managed their character's features in this game. Besides, Nintendo Company made a solid ground for itself with the launch of the game Donkey Kong. With the hype of arcade games that emerged in 1980s, young people spent over a billion dollars to play these games.

Gaming sector gained pace with the release of Commodore 64 computers with a price tag of approximately $600 in 1982. New steps were taken in gaming sector with the game Tetris that has been developed by Alexey Pazhitnow in 1985. Tetris game won great recognition with its basic graphics.

In 1989 Nintendo Company released mobile gaming console Gameboy. A cutting-edge era in gaming world has begun with Gameboy. Gameboy Company sold about 115 million Gameboy in 12 years. With the game, Mario Bros 3 that has been offered in Gameboy console a brand-new hype has begun with the rush of Mario Bros 3.


**Figure 4.** Game boy gaming console

After 1990s gaming sector accelerated. Lots of companies rapidly began launching their gaming consoles or games. Wolfenstein in 1993, Doom in 1994 and Quake in 1996 are released to the market as the best games of their period (Yılmaz, 2004).

In 1998, Half Life game that stormed through the world has been released. This game was a movie adaptation and gained the favor of various crowds.

Year 2000 became a great milestone for gaming sector. Quite new steps were taken for gamers with consecutive announcements of gaming consoles. Sony (Playstation), Nintendo (Gameboy Advanced), Microsoft (Xbox) companies created a great wave of excitement with their new console application releases. With the release of Sims game in 2003, a great step was taken for simulation games.

Gaming sector then became a market where great revenues are made. The improvement that took place from simple games of early periods to 3 dimensional games of today cannot be negated. Today various companies and people compete each other to obtain a place in this sector.

***History of Computer Games in Turkey***

Turkey first met electronic games in 1980s. Turkey became acquainted with gaming sector through Atari that was quite popular those days. Also, lots of our citizens met Commodore 64 computer towards the middle of that period. By this means, games came into our houses from Atari saloons ever after.

In 1990s, the newly emerging Internet cafes made young people who want to play games come together. With the penetration of other console applications to Turkey, many of our young people began gaming on various platforms.

However, advancement in terms of game development took place rather slowly in Turkey. Although it is not known by users all around the world, some advancement took place in our country.

Keloğlan game that was released in 1989 by Byte Computer were played on Commodore 64 computers. As for year 1992, a game named Hançer narrating the foundation of Ottoman Empire was released. In 1995, the game named "Legends of Istanbul: Tulip Warriors" was released.

Mevlüt Dinç, one of the popular names among Turkish game producers moved to Turkey in 2000 and proceeded his works here. His latest game named Dual Blades is among the unforgettable games of game boy fans. Today many people can develop basic level games. Considering today's technology and advancements of games, gaming sector is a business that is costly but profitable as well.

**Degign Tools Used for Educational Games**

***Adobe Flash***

Educational software, games, simulations, animations can be developed using Adobe Flash software. Adobe Flash is suitable for developing software for various platforms. It is favored by many people for its 2D and 3D support for users. We may develop very good applications on education using Adobe Flash that have been even more strengthened by Action Script 3.0 programming language.

**Figure 5.** Adobe Flash CC screen

***Unity 3D***

Unity 3D is one of the most favored softwares. Games and animations that are compatible with various platforms may be created using Unity 3D. Especially 3D users mostly prefer it. It offers its users many advantages thanks to its powerful engine and physical attributes. We may develop various educational software easily using powerful features of Unity.

**Figure 6.** Unity 3D screen

***Scratch***

It is a web-based programming language that has been developed by Massachusetts Institute of Technology (MIT). It is the most favored software by especially elementary and secondary school students. Because this software allows users to develop new softwares without requiring any software skills. Coding in Scratch is performed using blocks. Users add the predefined blocks in its library into each other to complete the programming. Using Scratch which is also supported by Ministry of Education, we may develop especially 2 dimensional applications easily and rapidly.


**Figure 7.** Scratch screen

***Kodu Game Lab***

It is a software developed by Microsoft. Computer and Xbox games may be developed using this software. Its primary objective is to teach programming while playing games. We may design entertaining and instructional games using this software which allows people that does not even have any coding skill to develop games. In this software games are designed using if conditions. Users apply if conditions to specific characters and attributes to design games. It is especially used in foreign countries to teach the logic of software development to kids in elementary schools.


**Figure 8.** Kodu Game Lab Application screen

**Literature Review on Educational Games**

Kaplan (2004) designed an educational computer game that may be used for instructional purposes in his thesis. Using this game model which is similar to Quest Atlantis educational game, it is aimed to teach kids in an entertaining way.

Tollefsrud (2006) proposed an editor software to develop educational games in his thesis. This editor software aims to teach students topics like mathematics, physics, and chemistry in an easy way.

Bruhn (2007) researched the effects of learning through simulation games on student success in his master's thesis. In his study, he lectured some topics to students using simulation games that are developed for educational purposes and investigated the effect of these games on students' learning skills.

Allen (2007) designed an educational game that is built on 4$^{th}$ grade mathematics syllabus in his thesis. Using this online game that is built as a MMORPG genre, students learned mathematics in an entertaining way.

Hangül et al. (2008) developed a mobile game that is used to illustrate the physics topic of projectile motion using three dimensional graphic technologies in their published article.

Gökdal (2008) designed an educational game for instructing engineering faculty students in his master's thesis. Designed game aims subjects to be learned very well by lecturing the courses taken by engineering faculty students using computer games.

Doğusoy and İnal (2009) published an article analyzing multiplayer computer games and their contribution to learning environment.

Ünal and Bay (2009) published an article attempting to execute computer aided teaching of Java programming language using the game they designed.

Güneş (2010) designed an educational game in MMORPG genre using Elektrogame and The Mana World in his thesis study. He contributed to elementary school 4$^{th}$ grade students' informatics course with the game he designed.

Fırat (2011) taught mathematics concepts to students by using the computer games he designed with animation software Flash in his thesis study. He confirmed the positive contributions of educational games to students in his study.

Akgün et al. (2011) published an article developing a new educational design model by examining the literature of design models used for educational game design process.

Genç and Karakuş (2011) published an article examining the convenience introduced by designing games using Scratch that is used to design educational games and its effect on students' opinion.

Gürbulak (2013) wrote a thesis on teaching pre-school kids the concept of colors using educational software developed by himself. He prepared an educational game that has a rich visual quality using animation software Flash. Thus, he mentioned how positively computer aided education contributes.

Aslan (2014) taught elementary school mathematics subject of probability questions by the educational game designed using Scratch software in his master's thesis. The students well comprehended probability problems with the help of this game. It is also observed that the attention of students has increased that are having fun while learning increases.

Yechshzhanova (2014) developed an educational game to help vocational high school students understand geometry course better in her master's thesis. She provided a better understanding of geometry course subjects to students especially with the help of effective utilization of 3 dimensional objects in the game she developed using Unity 3D software.

Demirtaş and Aslan (2015) studied the effect of game aided teaching to student success on instructing 5$^{th}$ grade course, acquisition of basic geometrical terms and drawing, in their article study.

**Educational Digital Game Based Model Implementation**

In this section, a simple game is designed using Kodu Game Lab software. The aim of this design is to teach students the "for loop" concept, which is one of the fundamentals of programming courses, hard to be comprehended by students and its mechanics is often confused in a simple manner. Our objective in the game that is developed simple enough to be understood by secondary school level vocational high school and upper secondary education students is to make them understand operating logic of two nested for loops.

When logged into the game, the robot character named Bilgin welcomes us. It is one of the main robot characters of the game that will assist us with annotations through the game.

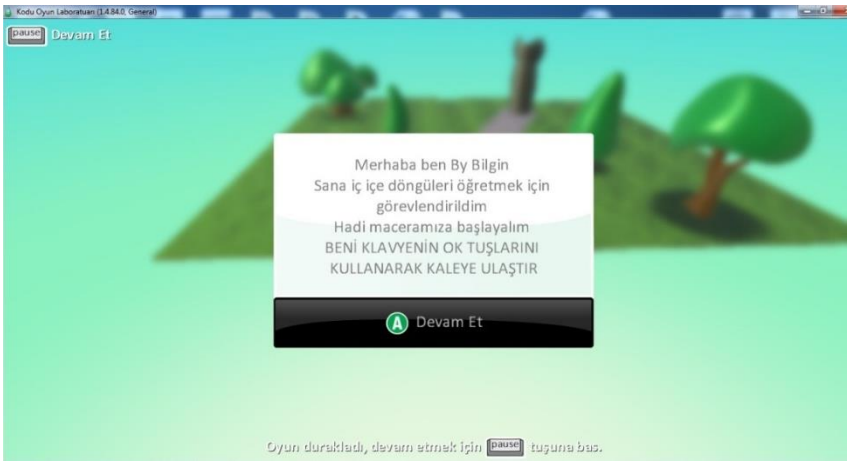


**Figure 9.** The reception screen of the game

After the reception screen, the game begins once our character is directed to the castle using direction arrows of keyboard. Bilgin gives us information on for loop and its implementation before the game commences.


**Figure 10.** The moment of reaching the castle

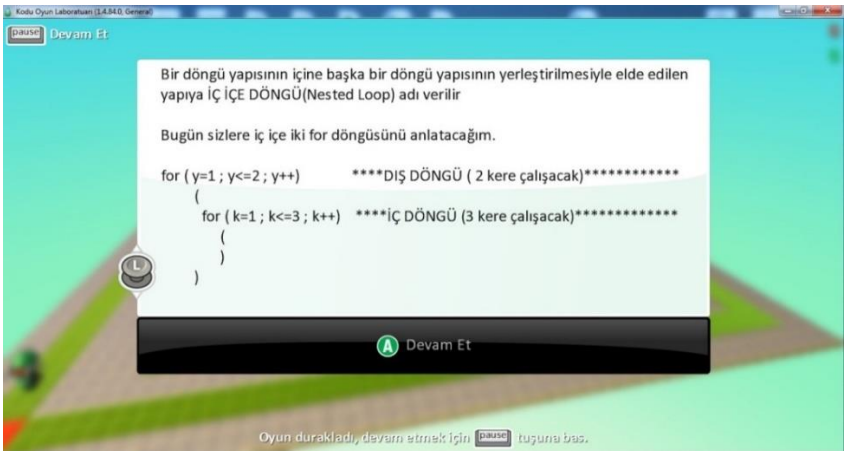


**Figure 11.** For loop information display

After going through the information display, two robocycles and two tracks will appear on our screen. These tracks represent our outer and inner for loops. The track displayed in green represents our outer loop while the track displayed in orange represents our inner loop.

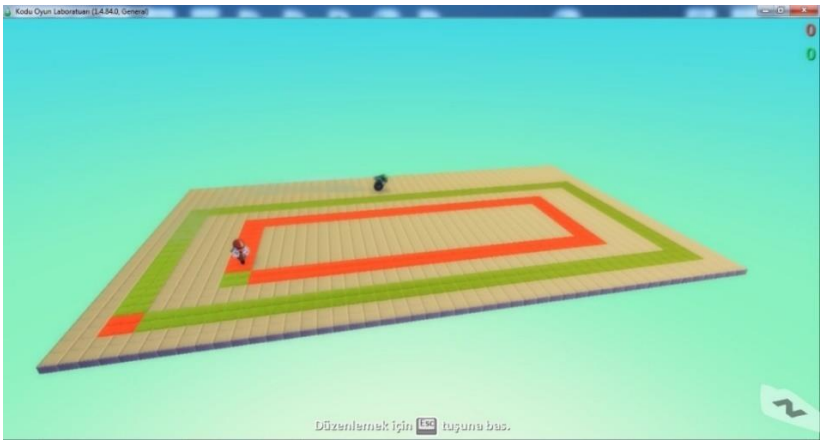


**Figure 12.** Game screen

Whenever the robocycle on the green track completes one round, the green counter on the top right corner of the screen increments by one. After green robocycle completes its round, Bilgin robot re-brief us again.

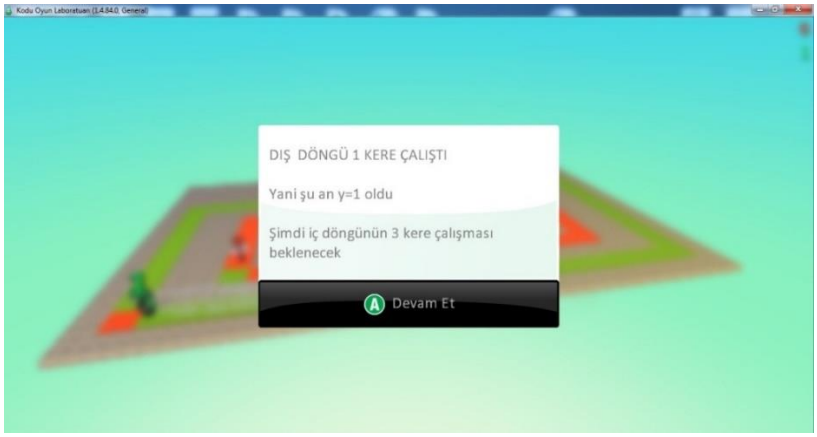


**Figure 13.** Outer loop information display

Green robocycle completing its first round indicates the first step of our outer cycle done its work. After the green robocycle stops, now our orange robocycle will begin moving and complete 3 rounds on its own track. Namely, our inner loop will function three times. The counter of our inner loop which is again on the top right corner of the screen will increment by one at the end of each round and when the counter hits 3, orange robocycle will stop.

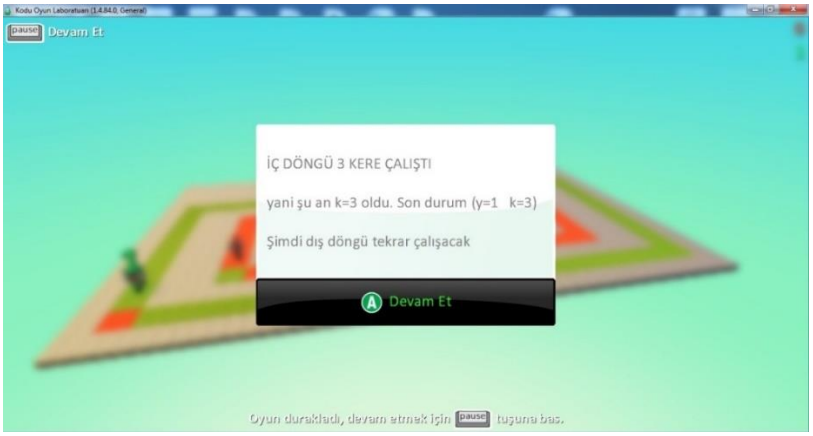


**Figure 14.** Inner loop information display

Inner robocycle will stop after completing three rounds and the green robocycle representing outer loop will once again begin its movement on its own track. Once the loop is completed, the counter representing outer loop will increment to two and green robot will stop again.

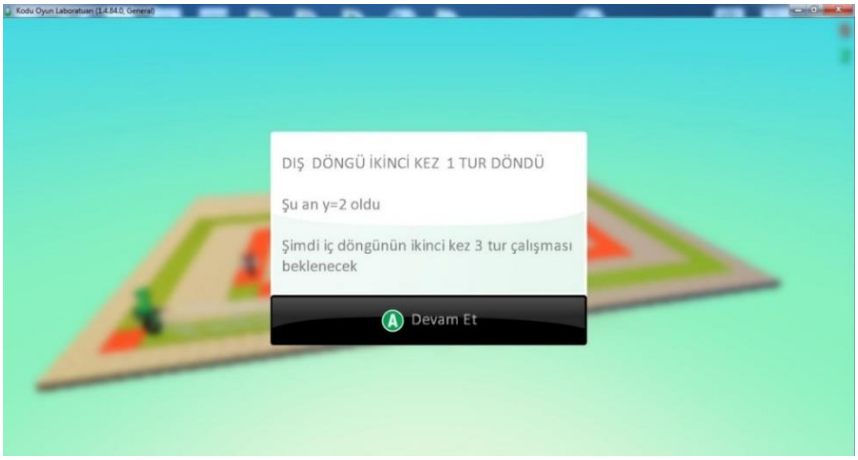


**Figure 15.** Outer loop information display 2

As soon as green robocycle stops, the orange robocycle representing inner loop will begin moving for the second time and complete its movement after taking three rounds. After completion of the rounds, our robot named Bilgin will step in again and will give brief information on processes conducted.

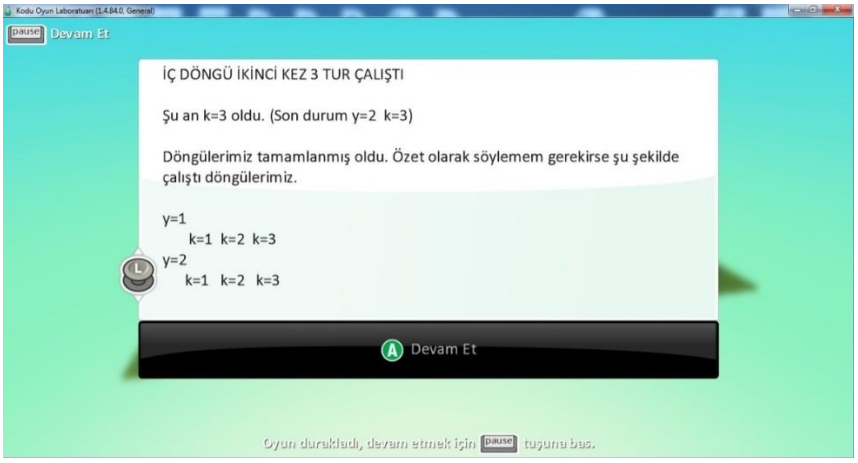


**Figure 16.** Summary screen

Finally, our robot will thank us and thus the game will be completed.

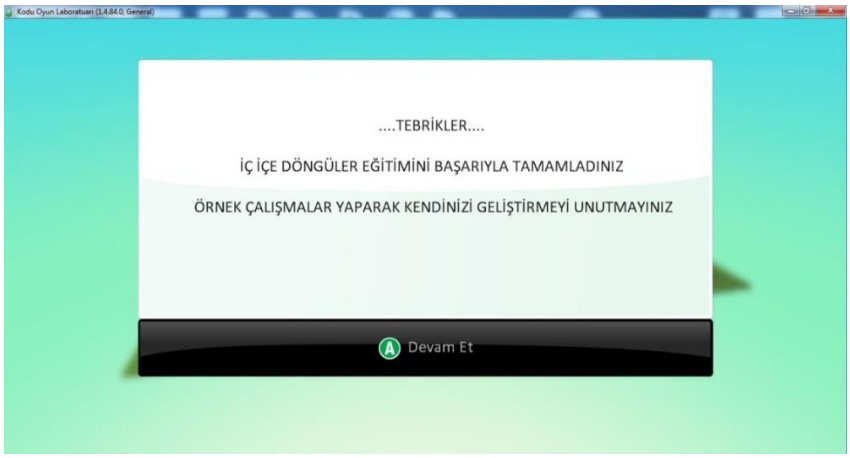


**Figure 17.** Game ending screen

With this designed game, visual illustration of the For-loop subject to students is intended. Its objective is to make students comprehend the subject better. The students will learn nested for loop concept in an entertaining way while playing a game.

## CONCLUSION AND RECOMMENDATIONS

Researches show that in terms of education, successful and efficient results in students' academic achievement and development of positive attitude against courses among students are accomplished by game aided education. As a result of the point that technology reached these days, there is always a computer or smart phone with us, at home, at school, shortly in every moment of our life. In todays world where computers and mobile devices are widespread and every user now runs processes through computers, perceiving the idea of game aided learning as learning through digital media is a more appropriate opinion.

Based on this requirement, by teaching students the subject of decision loop structures, which is one of the main subjects of computer programming and its operating logic is usually confused by students, with the aid of educational digital games, absorption of this subject by students in a manner that is entertaining as well as it is persistent is aimed. Our game will be developed in further stages and will be a guide for teaching processes of other computer programming courses' subjects with the aid of educational digital games

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# *Section 3: Math Education*

# PROSPECTIVE ELEMENTARY MATHEMATICS TEACHERS' CONTEXTUAL, CONCEPTUAL, AND PROCEDURAL KNOWLEDGE: ANALYSIS OF SELECTED ITEMS FROM THE PISA

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**ABSTRACT:** The aim of this study is to investigate the difficulties, which Turkish prospective elementary mathematics teachers have in solving the Programme for International Student Assessment (PISA) 2012 released items. Data were collected from 52 teacher candidates through a 26 item-written test. The data indicated that PISA items could be categorized according to whether they require contextual, conceptual or procedural knowledge. Analysis of data also indicated that the participants encountered problems mostly in items requiring the combined contextual, conceptual, and procedural knowledge. Although many of the participants could produce correct answers for procedural knowledge items, several could not, and few were able to give mathematical explanations and make appropriate estimations for conceptual knowledge items. The results lead us to conclude that the prospective teachers' contextual knowledge was generally fragmented, and that the role of the type of mathematical knowledge identified by PISA items should be explored with particular attention to the function of contextual knowledge. Implications for teacher education related to the findings of the study are discussed.

**Key words:** Contextual knowledge, conceptual knowledge, procedural knowledge, PISA items, preservice teachers

## INTRODUCTION

In recent years, much has been written about students' mathematics performance in international large-scale assessments such as Programme for International Student Assessment (PISA), Trends in International Mathematics and Science Study (TIMSS), and Progress in International Reading Literacy Study (PIRLS) (e.g., Andrews, Ryve, Hemmi, & Sayers, 2014; Roth, Ercikan, Simon, & Fola, 2015). There is ample evidence that the results of these cross-cultural comparative assessments caused a considerable stir in the worldwide educational community because of students' poor mathematics performance. Many articles suggested that mathematics scores were dropping out worldwide (e.g., Alphonso, 2013). This reaction is reflected in Turkey as well (Yücel, 2013), where mathematics education is either criticized or, if the country is placing bottom-down in the overall rankings, the distance to the achievement scores of the leading countries is noted as a major concern (Akyüz, 2014).

To this end, we focused on the *Programme for International Student Assessment (PISA)* initiated by the *Organisation for Economic Co-operation and Development (OECD)*. Scores on mathematical literacy items from the PISA is supposed to measure the extent to which students, at the end of their compulsory schooling (15 years), have acquired the mathematical knowledge and skills that are essential for everyday-life situations (OECD, 2006). The influence of such international assessments on both international (e.g., Boasen et al., 2014) and national education policy is considerable (e.g., Yıldırım, Yıldırım, Ceylan, & Yetişir, 2013). Results of these large-scale assessments are employed to develop curriculum planning and resource allocations. Henceforth, there is a need to analyze the items indepth and trace the difficulties encountered by the students in order to make educational decisions.

Simply put, the result was major debates pointing out the direct attention to the practice of teaching: if there is a need for effective learning then effective teaching is necessary. In this regard, researchers put their efforts in investigating what constitutes the mathematical knowledge for teaching and whether teachers represent that knowledge in a productive way (Hill et al., 2008). Drawing on these assertions, we assume that for teaching any mathematical knowledge the first requirement is to possess the knowledge. We suggest that this knowledge is not independent of tasks, and therefore the type of mathematical knowledge needed to reach a solution for a particular task. Accordingly, we carried out a study aimed at discovering the mathematical knowledge of students training to be elementary mathematics teachers when confronted with PISA items. Drawing on the results from PISA, researchers have shown that mathematical performance may operate differently across cultures (Chiu & Xihua, 2008; Chiu & Klassen, 2010; Kriegbaum, Jansen, & Spinath, 2015), but few studies have compared the preservice teacher performance in the particular released items in their analyses or explored categorizations of these items

concerning the type of knowledge they require (e.g., Olande, 2014; Sáenz, 2009). Examining the difficulties in PISA items might yield more indepth understanding of prospective teachers' mathematical knowledge that can be productively applied to problem situations.

The purpose of our study was to investigate the difficulties that preservice elementary teachers encountered while performing on PISA tasks that require using different types of mathematical knowledge.

## Theoretical Background

Recent research studies have shown that structured, organized knowledge enables individuals to perform tasks successfully and remember more relevant information than if we have only memorized isolated mathematical facts and/or automatized procedures (Bransford, Brown, &, 2001). According to Rittle-Johnson and Koedinger (2005), organized knowledge requires individuals to integrate their contextual, conceptual, and procedural knowledge within a content domain. In our study, we propose that information on these three types of knowledge will provide the whole spectrum of the context of PISA tasks, and provide empirical verification of the knowledge required for solving these tasks.

### *Types of Mathematical Knowledge*

In literature on mathematics learning and instruction knowledge plays a crucial role and is attributed a wide variety of types and properties. Types of knowledge are important for problem solving (Rittle-Johnson & Alibali, 2005), and that components of the knowledge base are characterized by the *function* they fulfill in the performance of a specific task (Gott, 1989). Mathematical knowledge can be thought of as consisting of three complementary types: contextual, conceptual, and procedural. A number of researchers offered definitions for both conceptual and procedural knowledge (e.g., Hiebert & Lefevre, 1986) and/or for the entire contextual, conceptual, and procedural knowledge (e.g., Rittle-Johnson & Koedinger, 2005).

*Contextual knowledge* is knowledge of how things work in daily life situations in the real world, which develops from our informal interactions with the physical world outside (Leinhardt, 1988; Saxe, 1988). Students' contextual knowledge can be elicited by presenting problems in story contexts (i.e., real-life settings), which are very likely to be unfamiliar. A large body research shows that many students have substantial difficulties in solving such non-routine problems (Lesh & Zawojewski, 2007; Schoenfeld, 1985; Verschaffel, Greer, & DeCorte, 2000). In relation to the present study, it is of value to take into consideration that the PISA strongly emphasizes the need to develop students' capacity to use mathematics in context, and thus stipulates contextualized tasks, which involve personal, occupational, societal, or scientific situations encountered in the daily life of a modern society. Contextual knowledge tasks in PISA, therefore require students to 1) translate from a real-world setting to the domain of mathematics, 2) identify the mathematical aspects of a problem situated in a real-world context, 3) recognize mathematical structure and representations (i.e., regularities, relationships, and patterns), 4) identify constraints and assumptions by mathematical modeling, 5) use appropriate variables, symbols, and diagrams for representing an everyday situation mathematically, 6) explain the relationships between the context-specific language of a problem and the formal language of mathematics, and 7) translate a problem into mathematical language or representation.

*Conceptual knowledge* is knowledge of concepts or principles and involves rich connections (de Jong & Ferguson-Hessler, 1996). It is characterized most clearly as a connected web of knowledge, a network in which the linking relationships are as prominent as the discrete pieces of information (Hiebert & Lefevre, 1986, p. 3). It is widely acknowledged that conceptual knowledge is essential for problem-solving (e.g., Rittle-Johnson & Koedinger, 2005). Conceptual knowledge tasks in PISA, therefore require students to 1) understand the extent and limits of mathematical definitions, facts and principles, 2) understand the extents and limits of mathematical solutions, 3) critique and identify the limits of the model used to solve a problem, 4) explain whether a mathematical conclusion makes sense in the real world context, 5) evaluate the reasonableness of a mathematical solution in the real world context, 6) analyze how the real world context impacts the outcomes of a mathematical procedure, and 7) make contextual judgments about how the mathematical results should be adjusted or applied.

*Procedural knowledge* is the knowledge of subcomponents of a correct procedure (Rittle-Johnson & Koedinger, 2005). It is defined as knowledge that is memorized by rote with some computational skills (Baroody, 2003). From this description, the essence of procedural knowledge is that it involves applying sequential action steps and automatized techniques for solving problems (Bisanz & Lefevre, 1990). Procedural knowledge tasks in PISA, therefore require students to 1) devise and implement strategies for finding mathematical solutions, 2) apply mathematical algorithms and structures when finding solutions, 3) manipulate numbers, algebraic expressions and

equations, and geometric representations, 4) manipulate graphical and statistical data and information, 5) construct diagrams, tables, and graphs and extract relevant mathematical information, 6) use and switch between different representations in the process of finding solutions, and 7) make generalizations based on the results of applying mathematical procedures.

Obviously, mathematical knowledge is complex in nature. Although the abovementioned definitions seem to be clear, mathematical knowledge may not be easily distinguished as one kind or to the other (Hiebert & Lefevre, 1986). Henceforth, meaningful knowledge of contexts, concepts, and procedures can be viewed as intricately and necessarily interrelated, not as distinct categories of mathematics (Star, 2005).

## METHODS

### Participants and Procedure

The sample consisted of 52 preservice teachers (38 females and 14 males) from Mersin University, Turkey. The participants were third-year (junior) students attending to Faculty/School of Education who were majoring in Elementary Mathematics Education. They had taken several courses in mathematics (e.g., Calculus, Linear Algebra) and mathematics education (e.g., Methods of Teaching Mathematics). Participants had no prior experience of the international assessment tests such as PISA.

The data were collected by the second researcher in the Spring semester of 2015-2016 academic year. A 26-item mathematics test which was originally released by the OECD (2013) was distributed to the participants as a booklet. The items adapted into Turkish, were released by the Ministry of National Education [MoNE], General Directorate of Assessment Evaluation and Testing Services (GDAETS, 2012, available from http://pisa.meb.gov.tr/?page_id=617). Participation was voluntary. The testing time for the entire mathematics test was approximately 90 min. Participants were also informed that the test was not to be considered as assessment and that; it would not be seen by other university staff.

### Data Collection and Analysis

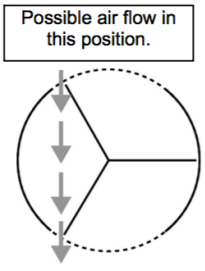
In this study, problems were categorized using the definition of contextual, conceptual, and procedural knowledge developed by Rittle-Johnson and Koedinger (2005). Each problem was coded so that it was included into one or more of the following three categories. The authors and another mathematics educator conducted the coding. Before each rater individually coded the problems, they discussed the interpretation of the categorization, which is based on the definitions of contextual, conceptual, and procedural knowledge. They met regularly to compare codes and identified the rationales for the categories. Although there was a significant overlap in the rationales, they discussed the different opinions about the problems reflecting types of knowledge. Afterwards, they separately coded the items and, met and discussed each of the coding discrepancies coming to 100% agreement for the data.

To clarify and discuss how we determined the type of knowledge, we present examples of items according to three type of knowledge: contextual, conceptual, and procedural (see Figure 1).

**Item 25.** Revolving door

The two door **openings** (the dotted arcs in the diagram) are the same size. If these openings are too wide the revolving wings cannot provide a sealed space and air could then flow freely between the entrance and the exit, causing unwanted heat loss or gain. This is shown in the diagram opposite.

What is the maximum arc length in centimetres (cm) that each door opening can have, so that air never flows freely between the entrance and the exit?




**Item 8.** Sailing Ships

Approximately what is the length of the rope for the kite sail, in order to pull the ship at an angle of 45° and be at a vertical height of 150 m, as shown in the diagram opposite?

A 173 m
B 212 m
C 285 m
D 300 m

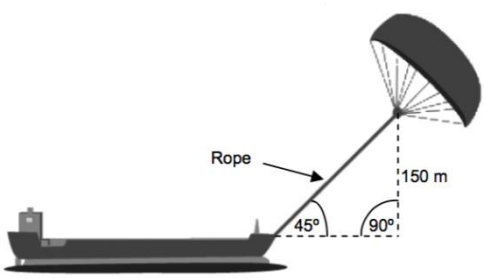



**Figure 1.** Sample items (OECD, 2013, p.13, p.34)

In Figure 1, Item 25 (*Revolving Door*) demands contextual, conceptual, and procedural knowledge because item provides everyday problems in the real world and non-routine applications (contextual knowledge), includes relationships and connections (conceptual knowledge), and requires calculation the length of an arc (procedural knowledge). Moreover, Item 8 (*Sailing Ships*) demands conceptual and procedural knowledge considering that it requires interpreting the visual representation of diagram (conceptual knowledge) but not the context of the problem and using Pythagorean Theorem (procedural knowledge). Test carried out by the prospective teachers and the difficulty of items was classified according to the percentage of correct answers to each one. In order to identify the errors according to the deficiencies in knowledge type, the responses of prospective teachers were analyzed further.

## RESULTS AND FINDINGS

Table 1 presents a classification from more to less difficulty of the tasks. Column 3 indicates the type of knowledge determined by the group of experts: contextual (Ct), conceptual (C), and procedural (P). Column 4 shows the percentage of correct answers given by the prospective teachers.

**Table 1.** Classification of the tasks by knowledge type and level of difficulty

| Item No | Task | Type of Knowledge | Percent Correct |
|---|---|---|---|
| 25 | Revolving door | Ct, C, P | 5.8 |
| 23 | Garage | Ct, C, P | 13.5 |
| 9 | Sailing ships | Ct, C, P | 23.1 |
| 18 | Helen the Cyclist | Ct, C, P | 38.5 |
| 3 | Drip rate | Ct, P | 46.2 |
| 8 | Sailing ships | C, P | 46.2 |
| 14 | Climbing mount Fuji | Ct, C, P | 46.2 |
| 15 | Climbing mount Fuji | C, P | 48.1 |
| 1 | Apartment purchase | Ct, C | 73.1 |
| 26 | Revolving door | C, P | 73.1 |
| 17 | Helen the Cyclist | C, P | 75 |
| 20 | Which car? | P | 80.8 |
| 22 | Garage | Ct, C | 82.5 |
| 11 | Ferris Wheel | P | 82.7 |
| 12 | Ferris Wheel | C, P | 82.7 |
| 13 | Climbing mount Fuji | C, P | 82.7 |
| 21 | Which car? | P | 82.7 |
| 24 | Revolving door | P | 82.7 |
| 10 | Sauce | P | 84.6 |
| 6 | Charts | C, P | 86.5 |
| 16 | Helen the Cyclist | C, P | 86.5 |
| 7 | Sailing ships | Ct, C, P | 88.5 |
| 5 | Charts | P | 90.4 |
| 2 | Drip rate | Ct, C | 92.3 |
| 4 | Charts | P | 92.3 |
| 19 | Which car? | Ct, C | 94.2 |

As seen in Table 1, an examination of the percentage of the prospective teachers who answered the tasks indicated that they encountered problems mostly in tasks requiring the combined contextual, conceptual, and procedural knowledge. Although many of the prospective teachers tended to outperform the tasks requiring procedural

knowledge, as expected, several could not, and few were able to make appropriate estimations for tasks requiring conceptual knowledge. For example, the most common incorrect answers given by the prospective teachers were included in task 25, 23, 9, 18, and 3. This was a valuable piece of information for the detailed explanation for the follow-up analysis of prospective teachers' difficulties related to the tasks in relation to the type of knowledge. Thus, we analyzed the most common errors and the difficulties with these tasks in the following sections.

***Task 25: Deficiencies in Contextual Knowledge***

Analyses of the errors in the most difficult tasks revealed that most of the prospective teachers had difficulty in understanding the context of the problem. In particular, most of the difficulties arose in the case of interpreting of geometrical model of a real-life situation, which was unfamiliar in the school mathematics. Task 25 posed an original problem whose solution demands non-routine applications rather than specific conceptual and procedural knowledge. The answers were in the range from 103 to 105 and 1/6th of the circumference was also accepted as another response. The most common incorrect response categories were $200\pi/3$. This error occurred while they misinterpreted the door openings (i.e., the dotted arcs in the diagram) and followed an incorrect procedure by calculating the length of an arc. In brief, prospective teachers showed a lack of interpreting and handling non-routine applications (or non-standard problem).

***Task 23 and Task 18: Deficiencies in Conceptual Knowledge***

There were some deficiencies in basic conceptual knowledge and some difficulties in elaborating visual aspect of the model in the problem. Task 23 poses an original problem whose solution demanded interpretation of a house plan and calculation of the total area of the roof using the Pythagorean Theorem. The complete responses were any value from 31 to 33. Moreover, the correct use of Pythagoras Theorem with calculation error and incorrect length used was also accepted as a partial response. The most common incorrect response categories were $17m^2$ and $2.5m^2$. These errors occurred while they were not able to elaborate the 3D view of the roof. As shown in the Figure 2, one of the prospective teachers drew the area of the roof and calculated the area of a triangle for the total area of the roof. This might explain the difficulty of elaborating the visual representation of the roof.

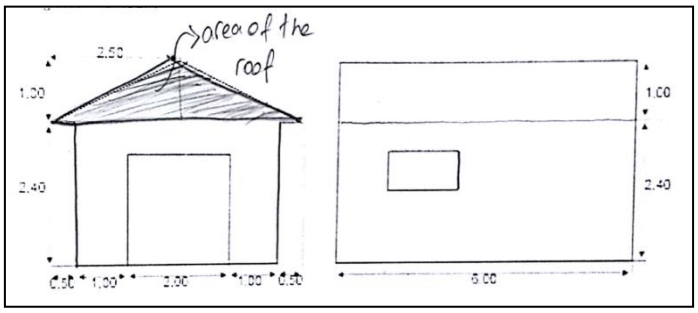



**Figure 2.** Example from prospective teachers' solution

Another important finding for the difficulties with the conceptual knowledge showed that the main error made by the prospective teachers consisted in calculating an average speed over two trips given two distances travelled and the times taken in task 18. For this task, the most common incorrect response categories were 20 and 85/3. They made an error in calculation of average speed considering that they calculated the average speed as an arithmetic mean of two speeds (i.e., they wrote the formula, (V1+V2)/2). This might be an indication of the deficiencies in basic conceptual knowledge.

***Task 3: Deficiencies in Procedural Knowledge***

Analyses of the errors showed that common difficulties and errors appeared in handling of formulae and calculating of equations, which revealed insufficient procedural knowledge. Task 3 required the handling of an equation (D=dv/60n) and substituting two given values. The answer of 360 could be obtained by a simple calculation of the volume in mL of the infusion. The most common incorrect responses were 6 and 90. These errors arose while many prospective teachers were not able to transpose the equation. In brief, they had difficulty in handling the variables and calculating the equations.

***Task 9: Deficiencies in Integrated Knowledge***

From the point of view of errors, there were three kinds of knowledge (i.e., conceptual, contextual, and procedural knowledge), which were of basic importance for Task 9. This task was based upon solving a real work situation involving cost saving and fuel consumption. It demands at formulating change and relationships. The answers were ranged from 8 to 9 years with adequate mathematical calculations. The most common incorrect response categories were 2 years, 3.5 years, and 4 years. Prospective teachers could not suggest a general relation between diesel consumption per year and cost for diesel without a sail. This shows a lack of understanding of conceptualization of connections among the cost savings and fuel consumption. Moreover, the problem containing very detailed information about sailing ship (e.g., the length, breadth, load capacity, and maximum speed of the sailing ship) and including the term "zed" was perceived as a negative aspect to the context. It was evident that the difficulties might arise in the case of sailing ships, which were unfamiliar to the participants.

## CONCLUSION

Beyond the well-researched phenomenon of conceptual and procedural knowledge, contextual knowledge has received relatively little attention within educational research. Findings of the present research showed that the majority of preservice teachers have rudimentary contextual knowledge and that they are not proficient in utilizing that type of knowledge while solving non-routine tasks. In a related vein, we also showed that assessment of the mathematical knowledge of inservice teachers includes assessment of the extent to which they have contextual, conceptual, and procedural knowledge, which they can productively apply to real-life problems in novel situations. Our data also support the assumption that a preservice teacher's mathematical knowledge is not only built on knowledge of concepts (i.e., conceptual knowledge) and knowledge of procedures (i.e., procedural knowledge), but also on the composition of the knowledge types in terms of knowledge of concepts and procedures, and on the knowledge of contexts (i.e., contextual knowledge). This information is of particular value for teacher educators, for whom the subject matter knowledge of their students should be a desired educational goal in itself.

## RECOMMENDATIONS

The simple message from this research is that preservice teachers encounter difficulties with performing tasks that require using integrated mathematical knowledge that is the blend of contextual, conceptual, and procedural knowledge. Within this amalgam, contextual knowledge is particularly important because it involves building relationships between daily life experiences and preexisting mathematical knowledge, and further transferring knowledge in a novel situation (Crowford, 2001). The utopian view would be for all preservice teachers to harmonize contextual, conceptual, and procedural knowledge; however, this is unlikely as it is almost inevitable that most preservice teachers tend to activate procedural knowledge while solving mathematical tasks. A more pragmatic solution might be for teacher education programmes to include more emphasis on the acquisition of contextual, conceptual, and procedural knowledge, and how these knowledge types are tied up with preservice teachers' understanding of particular mathematical content. On the side of the continuing professional development of inservice teachers a challenge might be that how appropriately acquired contextual, conceptual, and procedural knowledge is used by the teachers to develop students' mathematical thinking. The hope would be for preservice and inservice teachers to be able to grasp various aspects of acquiring contextual, conceptual, and procedural knowledge, understand the mathematical knowledge capacity of individual students, and guide them about how to mobilize knowledge types in the most productive ways. It is important that preservice teachers should understand the potential of their mathematical knowledge, types of mathematical knowledge in particular, to influence their future profession in the classrooms as inservice teachers.

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# CREATING REAL LEARNING EXPERIENCES RATHER THAN TEACHING BASED ON THE TRADITIONAL TRANSFER OF MATHEMATICAL INFORMATION, AT COLLEGE LEVEL

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**ABSTRACT**: Innovation in Education is a must in the 21st century education around the world. TEC de Monterrey in México as a system, is working hard in preparing and making their teachers innovate and use new educational models. Teachers are constantly implementing new teaching and learning techniques, not only to have better teaching practices in all fields, but to build life skills in their students. Competences such as collaborative work, problem solving, leadership and critical thinking are some of the skills that are cultivated through these techniques. A group of Mathematics´ teachers at Tec de Monterrey Campus León in Guanajuato México, have been using challenges in class as a way to create real learning experiences by using technology, flipped learning, mystery stories to improve reading comprehension skills and mathematical knowledge. Mathematics lessons have changed from simply transferring extensive amounts of information to creating the conditions for students to develop long life experiences. In a preliminary survey about math lessons in our campus, more than 54 % of the total students in this project, mentioned that they find math courses in general very hard, tedious, mechanical and without challenges. This study suggested that students learned math faster and deeply in a dynamic and fun way, 91 % of students in the final survey answered that learning math in this way was more meaningful and enjoyable, improving the enthusiasm about learning math among students. Math scores went up in the groups that followed this new educational technique.

**Key words:** Learning experience, dynamic, innovation, challenge.

## INTRODUCTION

We are living in times of significant change, our societies, institutions, businesses, occupations and the way we communicate and interact with others continue to evolve, therefore it is the responsibility of the educational community to generate new learning platforms, models and strategies that when implemented to the students will help them coalesce to the XXI century professional life. In the Tec de Monterrey, we strive to provide relevant learning experiences that include hands on experience in the community and an important level of maturity to deal with different cases, situations, problems and projects. As Karl Fisch so wisely stated in 2007 (Fisch, 2015) "We are currently preparing students for jobs that don't yet exist, using technologies that haven't been invented in order to solve problems we don't even know are problems yet", and our challenge as educators consists of taking advantage of our students' years with us, so as to help form the future leaders of these changes.

We live and learn with every aspect of our personality. When we combine our emotional knowledge with our physical knowledge, we achieve true human learning, which, according to Claxton (Claxton, 2008) occurs when we no longer know what to do, and therefore any learning experience will pose a certain risk, a gamble in which we must accept uncertainty free from any anxiety or anguish, living each new challenge as an element of a complex society in which a culture for learning will emerge that will stimulate the individual's confidence in his or her learning ability in any situation. Let us embrace this idea and allow every student to actively experience their responsibility for their own learning and that of their teammates, (Gomez, 2016) following a determined set of instructions, training and actions that based on technology and several communication strategies will develop personal and social skills which will transform into a habit of collaborative learning.

Although we will not generalize, it is a common to find in students entering higher education in Mexico, that a large percentage of them deem certain subjects as too difficult, rejecting fields such as mathematics, arguing that

it is a boring and useless branch of education. According to a survey conducted by the National Survey of Habits, Practices and Cultural Consumption by CONACULTA (Cultura, 2010), 77 % of the population of Guanajuato reported not reading any books, 49% reported not reading newspapers and 58% never reads magazines. With this data, it came as no surprise that in 2012 of the 108 countries that make up the UNESCO, Mexico has the next to last place in reading index, estimating that a mere 2% of the Mexican population has a permanent habit of reading.

## METHODS

The pedagogical proposal presented in this innovation project was to promote the passion for reading while simultaneously uncovering the charm behind the world of mathematics, for this purpose the book: The Mathematical Novel was included in the classroom and homework sessions, thus allowing the students to experience a more individual and collaborative approach to the numerical challenges presented in this book, along with weekly activities associated with the Schoology educational platform.

### Text Selection and Generation

One of the motivators behind this project was to increase each student annual reading tally by at least one book by the end of this mathematics course. For this reason, choosing a book that would be of an attractive genre and writing style for students between the ages of 18 and 21 was of paramount importance. A murder novel was chosen; in which the challenge was to discover who the killer was.

To generate empathy, the novel revolves around four young university students who witness the last minutes of life of the city's ruler, whom explains to them the importance and the negative impact on the community if they do not catch his murderer. Therefore, with his dying breath of air, he urges them to catch his murder and he gives them the first clue that they must follow. Coincidentally, the beginning of this novel also elaborates on the traits and hobbies of the students, who share a dislike for mathematics.

Each chapter of the novel includes two elements that allow the reader to link mathematics with reading comprehension innovatively:

- One challenge (from a total of 9) that they must solve and send online to the city's ruler to demonstrate that their investigation is on the right track. To solve this challenge, it is necessary to use the mathematical knowledge and skills that were presented in class each week.
- One clue (from a total of 9) that can be solved by using mathematical logic, deduction and common sense that have been acquired in previous stages of the students' life. This clue will allow the characters to continue their search and come closer to finding the murderer's hide-out.

### Activity Distribution for the Students

This activity was designed to be implemented in 12 weeks, the project began with a survey of reading habits, and the students' opinion about the relationship between learning about math and reading comprehension.

- During the first project class, when the project was presented, the students were divided into groups of four and roles were assigned, stressing the importance of individual work, which in this case consisted of reading the chapter pertaining to each week; and teamwork which consisted in
    - one student who would be responsible for organizing the time allotted in the classroom,
    - one responsible for formalizing a proposed solution,
    - one in charge of questioning and validating the results,
    - and finally, another that would deliver the work to the platform.
- During the first two weeks, the students had to read chapter 1 and 2 respectively and during class on Fridays they would take a reading comprehension quiz. This phase helped determine each student's initial reading comprehension level as well as introducing the story to the students.
- From week 3 to 11, the individual reading was divided into two parts:
    - The first part of the corresponding chapter was made available every Monday, in which the characters are confronted by two elements: a challenge and a clue. To have time to read the chapter and propose solutions individually the students disposed of half a week, since during class on Thursdays, the students were given time out of class destined to work collaboratively on solving both elements, generating evidence and come to a proposed solution which must then be uploaded to the Schoology platform.
    - The second part of the chapter becomes available for the students to read from Friday to Sunday. During this section of the chapter the characters describe the correct solutions they reached and

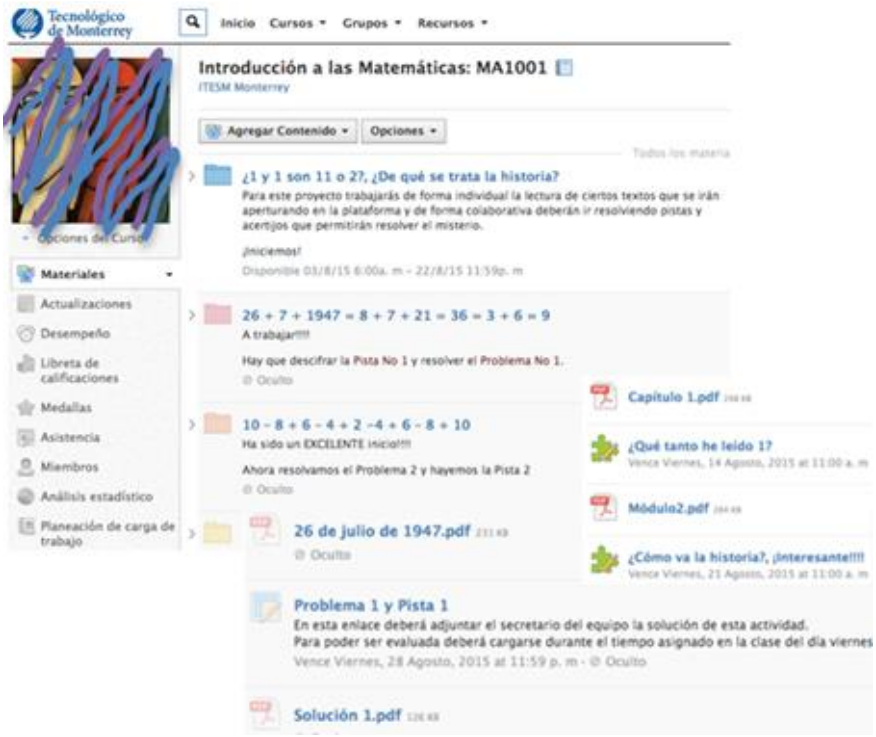
they continue their search. This way the students can effectively compare their proposal to that of the characters' and witness the correct interpretation of the challenges and clues.

- From weeks 6-12, during class on Fridays, students were evaluated individually and online regarding the elements that were described in the chapters, so as to measure the variation in reading comprehension.
- During week 12, and after each team handed in their proposed solution to the ninth and final challenge and clue, the final solution and conclusion to the mystery of the novel became available on the platform.
- During week 13 the students were again surveyed on their reading habits and their opinion of the relationship between learning mathematics and reading comprehension.

**Implementation**

This project can be found on the Schoology platform and was implemented on the students of the August-December 2015 semester of the class MA1001 Introduction to University Level Mathematics, which is integrated by students who are lacking in some of the required areas to begin mathematics in their corresponding careers.

To begin the semester, the platform was organized and each student was given clearance to access it. The two surveys were uploaded, along with three reading evaluations, the 9 block, including the readings with the problems that must be solved and the clues that must be deciphered, as well as the solutions that were reached by the characters from the novel and the 9 spaces in which each team must turn in the result of their work. Each of these elements was programmed so that it would only become visible to the students after a specific date.




**Responsibility of the Teachers**

The development and implementation of this project required the collaboration of several teachers that were in charge of different responsibilities: a language teacher was responsible for writing the novel, a mathematics teacher was in charge of the problems and mathematical challenges that were related to the subjects covered each week as well as programing the math classes into the semester; an instructional designer validated the pedagogic proposal and uploaded the program on Schoology, and last but not least, was the teacher in charge of accompanying and evaluation the students' work, who also was responsible for encouraging individual reading and emphasizing each team's responsibility of uploading their work onto the platform. Each week the teacher evaluated each of the solutions and assigned the appropriate sticker to each development, it is important to note that the although the solution might not have been accurate, creativity, enthusiasm, team work and strategy were evaluated, so as to encourage the passion for math and reading.

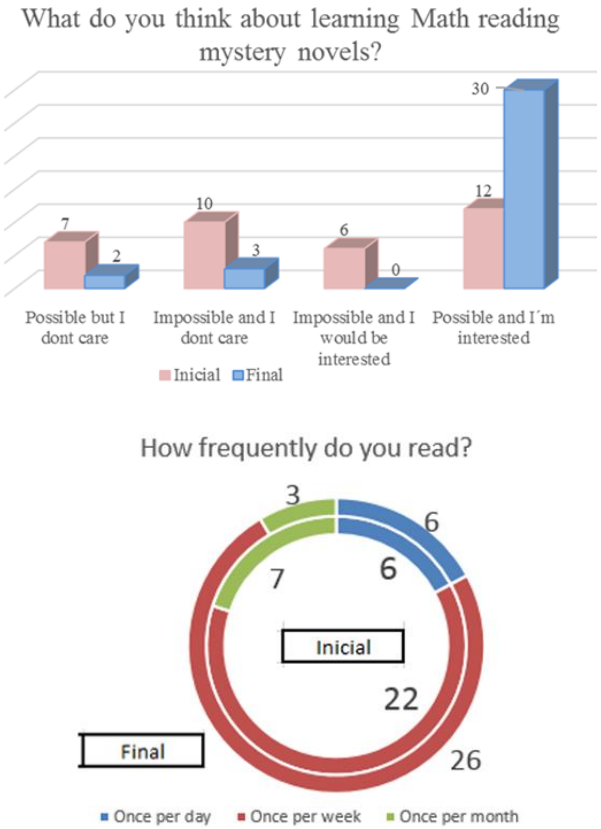
The team of professors that collaborated in this project would record weekly incidences to measure the project's effectivity and implement improvements, in which the following variables would be reported:

- The planned activity could be carried out, virtual activities were completed each session by means of the platform,
- All products or evidence were handed in/received in time for their evaluation,
- Instruments were employed -such as rubrics and checklists- from the platform to evaluate the activities,
- Describe the reasons that lead to registering an incidence or lack of.

## RESULTS

To evaluate the project, two variables were considered. On one side, the students interest and perception for reading and the possibility of improving their mathematical skills reading, and on the other side, their competence in solving mathematical reasoning problems as well as their reading comprehension, both of which are basic for the Plan 2020 of the Tecnológico of Monterrey.

Considering that the project included the months of August to November, 12% of the participating students reported a change in their reading habits from 1 time a month to one time a week. There was also a significant increase of those of the sample who believed they could learn mathematics reading a mystery novel, at the beginning of the semester 34% believed this affirmation was possible, whereas by the end of the semester 86% agreed with this affirmation.




**Figures 1 & 2.** Results at the inicial and final of the project

Regarding the reading comprehension competency measurement of the project, the group had an average of 46/100, 85/100 and 78/100, which was related to the increasing number of visits to the course on Schoology and the time each student was connected to the platform. As time the semester continued, these indicators also increased, demonstrating a 69% rate of improvement of their reading scores as measured by their level of retention, comprehension and memorization.

As far as the work turned in regarding the mathematical clues and challenges, these evaluations also demonstrated an evolution in the group average since they were of 76/100, 87/100 and 93/100 at the midterm cut. This

demonstrates an improvement in their competence for logical reasoning and mathematics. It is important to mention that even by the second evaluation, the students continued to question the validity of the evaluations since not all of the elements in the book had yet been covered by their math sessions; however by the last delivery dates, this was no longer and influential factor and the academic achievement rose by 22%.

These numbers allowed us to consider the project succesful, however these are some of the comments we received from the students:

- It was easy to read and solve the problems as a team because we helped eachother out.
- I liked that the lectures were programed and distributed from the start. We got better at how we solved the problems and we also helped each other with the reading.
- Schoology's claneder would let us know via email about the deadlines on the reading, which was helpful, especially since there was a lot of reading for some of the weeks.
- During exam week, I lost the thread of the story.
- I don't like reading, and I didn't like that I had to read to do math, however this semester I read this book.

that inspire us to keep inovating, creating more stories and new ways to make their learning experience more meaningful.

## CONCLUSION

The objective of this project consisted in implementing some of the tools proposed by the Model Tec21 to improve the students' abilities by joining two elements, mathematics and Reading. One of the most important findings of this project was that the students were able to learn in a completely different way, without so obviously following a lesson plan, the learning experience became something innovating, stimulating and challenging. In the students' mind, it seemed impossible to imagine that a mystery novel would hold all the elements of a math program. It was also equally gratifying for the students to discover that their preconception that "I was born bad for math and for problem solving" was nothing but a myth. The students were able to propose creative and insightful strategies to find the solutions to the clues and challenges from the novel. Although they sometimes doubted their proposed solutions because they recognized it did not fully adhere to the methodology proposed in the classroom, they discovered that there are several different ways to apply their knowledge to solve a problem. This project would have been demonstrated less effective results if we had not integrated several of the elements that these new generations learn and work with, including: the importance of knowing their role in a team, so as to guarantee their participation in teamwork, the use of a technological platform not only made the reading easier, it also enhanced the follow-up, turning in the assignment and the feedback from each student. These elements made the project more familiar and pleasant for the students.

## RECOMMENDATIONS

The next step consists in inviting more teachers from different areas to join us in linking their corresponding subjects to a good story. This project won't only apply to mystery and mathematics; it applies to any subject in which the student can take their knowledge and the information they learn in class to a fun, imaginative context in which they can practice it.

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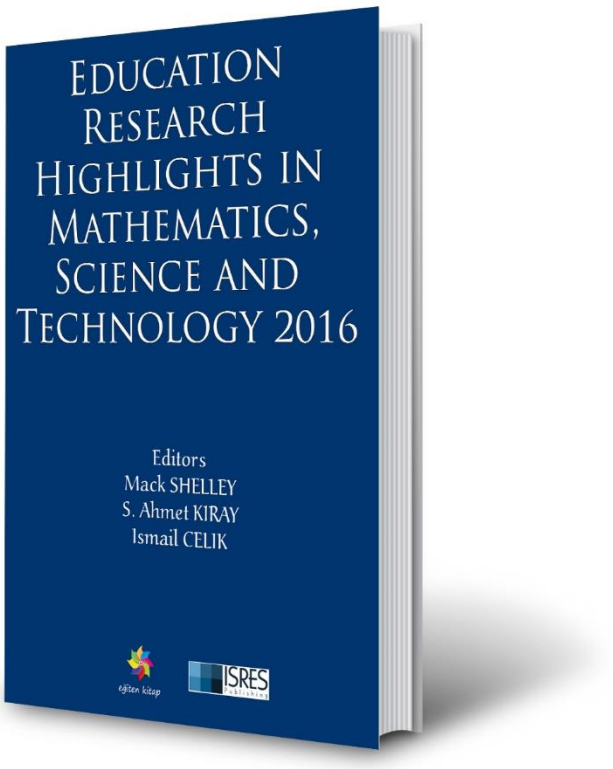


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