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Parvaneh Amiripour[1],
Islamic Azad University, Iran

Rouhollah Khodabandelou[2],
Alzahra University, Iran

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[1] Department of mathematics, Science and Research Branch, Islamic Azad University, Tehran, Iran
[2] Department of Education, Faculty of Psychology and Education, Alzahra University, Tehran, Iran

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Parvaneh Amiripour, Islamic Azad University, Iran Parvaneh.amiripour@gmail.com
Rouhollah Khodabandelou, Alzahra University, Iran khodaband@gmail.com

Abstract: Previous studies have shown that working children are at risk of financial, cultural, and educational damages due to the street-working and street-living conditions. In Iran, the issue of educating the working children has always been a concern for the community officials. Due to the conditions that working children have in Iran, they suffer from academic failure, especially in subjects such as mathematics. Therefore, the aim of this study was to investigate the effectiveness of teaching based on educational neuroscience strategies on the mathematical performance of working children. Therefore, through Pre-test-Post-test control group design, the ten steps of educational neuroscience strategies were implemented for 23 male and female Afghan children in two basic mathematical topics of the third-grade elementary school. In contrast, in the control group, 20 male and female Afghan children were assigned into the same grade and undergone the traditional instruction of the same topics in the two educational centers of working children in Molavi and Naser Khosrow districts in Tehran. The ANCOVA test results obtained from the researcher-made mathematical test showed that the instruction based on educational neuroscience strategies were effective on the mathematical performance of working children. It is suggested that teachers pay more attention to the individual-learning differences of the working children in using the steps of neuroscience-based instruction, in order to prevent their academic failure, and constantly take the right steps in teaching based on educational neuroscience strategies, all of the other courses like in mathematics

Resumen: Estudios previos han demostrado que los niños que trabajan corren el riesgo de sufrir daños financieros, culturales y educativos debido a las condiciones de trabajo en la calle y de la vida en la calle. En Irán, la cuestión de la educación de los niños trabajadores siempre ha sido una preocupación para los funcionarios de la comunidad. Debido a las condiciones que tienen los niños que trabajan en Irán, sufren fallas académicas, especialmente en materias como las matemáticas. Por lo tanto, el objetivo de este estudio fue investigar la efectividad de la enseñanza basada en las estrategias de la neurociencia educativa sobre el rendimiento matemático de los niños que trabajan. Por lo tanto, a través del diseño del grupo de control Pre-test-Post-test, se implementaron los diez pasos de las estrategias de neurociencia educativa para 23 niños afganos masculinos y femeninos en dos temas matemáticos básicos de la escuela primaria de tercer grado. Por el contrario, en el grupo de control, 20 niños afganos varones y mujeres fueron asignados al mismo grado y recibieron la instrucción tradicional de los mismos temas en los dos centros educativos de niños trabajadores en los distritos de Molavi y Naser Khosrow en Teherán. Los resultados de la prueba ANCOVA obtenidos de la prueba matemática realizada por el investigador mostraron que la instrucción basada en estrategias de neurociencia educativa fue efectiva en el rendimiento matemático de los niños trabajadores. Se sugiere que los maestros presten más atención a las diferencias de aprendizaje individual de los niños trabajadores en usando los pasos de la instrucción basada en la neurociencia, para prevenir su fracaso académico, y constantemente dar los pasos correctos en la enseñanza basada en estrategias de neurociencia educativa, todos los otros cursos como en matemáticas

Keywords: Mathematics; Educational Neuroscience; Brain Function; Performance; Working Children

Palabras clave: Matemáticas; Neurociencia educativa; Función cerebral; Rendimiento; Niños que trabajan

1. Introduction

One of the fundamental problems of science is creating a link between fundamental studies and the daily human life. Everything that we observe to be successful and modernized in the society is due to such a relationship. Researchers believe that it is possible to create a link between mind, brain and education. This belief roots in the cohesive relationship between neurobiology and cognitive science in societies (Fischer, Bernstein, & Immordino, 2006). The findings of previous studies on brain functions and how its works, triggered the emergence of new forms of knowledge about the relevant topics such as memory, motivation, thinking and learning, along with the development of thought (Varma, McCandliss, & Schwartz, 2008). Such studies provided educators and teachers with the knowledge about brain functions and learning development, which made them to create a sustainable relationship between the two neural and educational fields, by searching about educational science, along with teaching-learning neurobiology (Frith, 2005). The field of educational neuroscience is known as one of the new fields of study. In this field, the relationship between educational science, neuroscience and neurology can be observed, which makes this field to be considered as an interdisciplinary science. This field of study is one of the epistemic emerging fields, which looks at the individuals' brain and neural structures and functions, from a cellular-system perspective (Bransford, Brown, & Cocking, 2008).

The link between educational science and neuroscience in the field of educational neuroscience has the potential to enhance brain functions, thinking and performance in the teaching and learning domain. Adaptation of brain functions to the environmental conditions and permanent changes is required for such a link. Educational neuroscience is a way to promote such a link. The learning process occurs during the changes in the brain function system, and the teaching process is like a leverage to change these functions and the brain, in order to provide new links between the stimuli and the learner's experiences. Studies show that teaching based on learning facilitating strategies, leads to the process of information between stimuli and the brain. Successful learners are those who can create this link. Teachings based on educational neuroscience embody the active and thought-provoking educational approaches. Active approaches and engagements in learning include concepts such as educational planning that adapts to the learners' learning-thinking- development style, encouraging the learners to participate in processing the ideas and exchanging the information, teaching and evaluating in a variety of ways, utilizing mental and physical capabilities in teaching-learning process, providing experiences and situations that facilitate learning and make it meaningful, creating opportunities to enhance reflection and thinking and providing an opportunity for meta-cognition, deeper engagement in focusing and learning, creating an opportunity for lifelong learning, curriculum designing in line with everyday life, processing in a tangible way, such as the use of practicing for meaningful learning of concepts. In order to educate students who, have higher-order thinking ability and view issues from a broader perspective, the students must integrate their thinking and brain functions with the stimuli and have a critical perspective, therefore creating such situation is the responsibility of the education system and requires the use of emerging and active skills in the teaching-learning process. Traditional teaching methods and the teacher-centered approach mostly focus on dictation of lesson activities and the temporarily retaining of the lesson concepts. In this approach, learner activation and participation do not take place, and the learner begins to learn in an environment that students are supposed to be silent and no emphasis is placed upon their brain functions. Therefore, the link between stimulants and the nervous system would not be established. Hence, researchers are seeking to establish such a link, in order to form a learner-centered environment (Parmelee, Michaelsen, Cook, & Hudes 2012).

The issue of educational neuroscience strategies was chosen to be considered for a group of vulnerable people (that is, working children). In contrast to what is commonly assumed, working children have no major problems, defects, or disabilities, whether mentally or physically. No incompatibility or lack of flexibility with the cultural and social norms has been observed in their behavioral and individual characteristics. Considering this issue, mostly the personal problems and some groups of working children are considered in this study, rather than considering society problems or the community damage (Azad Ermaki & Bahar, 1998).

In Iran, the majority of working children are the Afghan children who emigrated from Afghanistan to Iran, due to the war. This group of children did not have the right to study in Iranian schools due to their immigration and not having the residence cards[3], so they were receiving education and acquiring life skills at some charity centers. Since the charitable people in these centers in Tehran who were engaged in teaching working children at elementary school level, were not attended teacher training courses, therefore many Afghan children in these centers face educational problems such as academic failure in mathematics. Due to its abstract nature, mathematics is significant for children, especially for working children with respect to their problems in life, more than any other subject. The teaching approach is one of the basic principles of mathematical curriculum planning. Teaching helps to understand and comprehend mathematics, to improve the ability to solve mathematical problems, to build confidence and self-esteem, and to create an attitude and perspective towards mathematics. Therefore, it can be argued that the improvement of mathematical education is dependent to the efficient teaching of mathematics. However, the efficient mathematical teaching requires the information including the concepts that the learner needs to learn, what the learner is looking for and the way of finding an effective solution when the learner faces challenging and confronts difficult mathematical problems (National Council of Teachers of Mathematics (NCTM, 2000). On the other hand, it must be argued that the efficient mathematical teaching is a rigorous and complex approach, and there is no single teaching instruction to dictate teachers how to implement teaching and so being given to them regularly, and they follow this instruction. Studies show that mathematical teaching can be effectively cited if teachers have a deep understanding of mathematical meaning and can efficiently present mathematical skills in class. Teachers should trust in learners and believe that they can have the actual growth. Teachers must have the ability to select and apply multiple strategies for solving mathematical problems, therefore with this approach; the efficient mathematical teaching requires thinking and applying functions in the teaching procedure and an unplanned activity in the way of achieving the methods of performance improvement and growth and applying the emerging solutions (NCTM, 2000).

An example of studies that is similar to the current study is that of Campbell, Cimen, & Handscomb (2009), where in a study on learning and understanding the division: a study in educational neuroscience, they investigated the degree of learning progress and the understanding of in-service teachers towards rational numbers, division and the relationship between these two, along with a computer-based learning environment in the form of educational neuroscience, and they found the relationship between the components of counting, calculation, estimation, and symbolic and graphical representation, and noticed the differences between these components. Verschaffel, Lehtinen, & Van Dooren (2016), in a study on neuroscience research towards thinking and learning mathematics, showed that there is a relationship between cognitive neuroscience and mathematics from the viewpoint of mathematical education. Dündar & Ayvaz (2016) in a study on cognitive and educational neuroscience showed that there is a relationship between cognitive and educational neuroscience studies. However, there still are ongoing researches in this domain to determine which one is better acquired. Sadeghi, Behrangi, Abdollahi, & Zinabadi (2016) in a study on the effect of educational neuroscience strategies-based educational management on learning improvement, showed that educational neuroscience strategies-based educational management is more effective than the traditional teaching methods and recommended applying this model in teaching practices. Given the importance of mathematics learning for the children with specific conditions that have been introduced in the present study, the need to use distinct teaching strategies, different from the teaching strategies used for teaching such children for elementary school mathematics learning finds more importance. Therefore, the researcher seeks to answer the question of whether educational neuroscience strategies-based educational management is effective on the mathematical performance of working children or not.

[3] Prior to October 2015, Afghan children were not permitted to study in the Iranian schools without having residence card. This law was revoked from October 2015 by the order of the Supreme leader of Iran, Ayatollah Khamenei.

2. Educational neuroscience

The educational science used science to strengthen its theoretical and empirical foundations, but after the revolution and the evolution of cognitive science and the achievement of researchers to the innovations and imaging of the brain structure in the last decade, some changes occurred in this science, so that the fields of bio-neuroscience, cognitive psychology and social cognition and cognitive anthropology were emerged. Given the revolution that has occurred in science-education centers, the establishment of the relationship between neuroscience and education is the continuation of the effort that has been made in the past years to make education scientific. Currently, these efforts have been presented with various titles such as Neuro-educational studies, Brain and Education, or Brain and educational Sciences (Howard-Jones, 2011). Naming the 1990s as a decade of brain promoted the researchers' desire to study neuroscience in education. In the meantime, the research on the learning and studying of the brain began (Blakemore & Frith, 2000). In the first phase of this research, which lasted until 2002, the implications of brain research were identified, and in the second phase, from 2002 to 2006, the barriers and challenges that these types of activities had created for reading, writing, mathematics, and science throughout life, were raised. Educational neuroscience, studies the brain's structure and functions and the neuro-brain system; and it is one of the complex sciences that is gradually entering the different areas of life (Jensen, 2000). At the beginning of the 21st century, the success and achievements of human brain neurobiological studies prompted scientists in the domains of humanities and social sciences to study the implications of brain consciousness. Jensen (2008) believed that the neuroscience had more applications in education than in other areas, so that a new field, called educational neurology is emerging to apply functional imaging techniques in learning and teaching studies. In recent studies of educational neuroscience, a new concept of learning has been presented. In this approach, learning stands for the formation of new dendrites or new brain structures (Varma et al., 2008). In other words, learning changes the brain's physical structure and, consequently, its functional organization. In the same way, the structures and functions of the brain will be organized and reorganized for learning takes place. Therefore, the study of the nature and manner of learning is the link between neuroscience and education (Goswami, 2004). This common ground made many researchers to try to improve teaching practices, by focusing on brain-based learning. Therefore, a strong link can be established between neuroscience and education.

3. Research method and procedure

The research method is in accordance with the Pre-test-Post-test with control group design. The researchers implemented the educational intervention based on the educational neuroscience strategies in teaching the third grade of elementary mathematical concepts in the experimental group, while in the control group, traditional method of teaching was used. Teaching based on educational neuroscience was implemented in a way as it will be described. The duration of the procedure included a three-month training course, with three sessions a week, and 40 to 45 minutes per session. The steps of the educational neuroscience-based teaching strategies (Behrangi & Taghipour Khalefloo, 2012) are as follows:

Step 1. Organizing the main concepts and topics of the concepts of addition and subtraction in numerical and verbal forms, and in the form of maps and diagrams.

Step 2. Creating an image of the general and partial topics of addition and subtraction concepts, in numerical and verbal forms.

Step 3. Formative assessment with the aim of student / students' preparation based on Map / diagram in mathematics: Repetition and rehearsal methods are used to improve memorizing and remembering the previously learnt contents of addition and subtraction in numerical and verbal forms.

Step 4. Forming some groups to implement a general and mental image of students in the communication map between mathematical concepts and addressing the students' talks /

problems: In this case, the main concept of addition and subtraction were divided into sub-sections is numerical and verbal forms, based on which the learning groups were formed and the students were gradually learning the relevant concepts. At this time, the researcher asked each group to compare their own mathematical activity. If a problem or an objection from a group were reported to the researcher, he tried to create a referendum and increase self-esteem among the students, seeking a logical reason to prioritize mathematics activities.

Step Five. Drawing the communicating map/ diagram which link between the main mathematical topics and subtopics, again. While in each group, students were interactively engaged in learning addition and subtraction concepts numerically and verbally, by observing and scientific imitation of the students in other groups, they learned how to model and criticize the critics and recommendations of the other groups.

Step 6. Comparing and evaluating the diagram / map drawn by the students with the main diagram / map: In this situation, the goal is to examine the difference between the cognitive construction of the student's mind with the main knowledge and how the students compare themselves with others. In this step, the student will have the opportunity to have a better and simpler understanding of addition and subtraction concepts in numerical and verbal forms.

Step 7. Providing a modified group made diagram / map in order to reach the ideal chart / map: In this step, all students try to collaborate and harmonize their own understandings and achieving a general map / diagram of the relationship of concepts; so that they will ultimately reach an overall agreement. In this step, it is observed that the students move from the stage of recognition to the stage of metacognition.

Step 8. Presenting the totality of teaching the content of addition and subtraction concepts, in numerical and verbal forms: This step deals with program designing and the implementation of management in the mathematics classroom. In the previous stages, students and the researcher were engaged in working on mathematical content and learning that specific concept. At this stage, students and the researcher can provide a teaching and learning approach for any mathematical concept, in accordance with their level of growth and learning, along with the technologies and manipulative appropriate to that mathematical concept.

Step 9. Implementing the instruction: It is expected that the appropriate teaching model be selected and implemented in accordance to the students' learning and individual differences. In some groups, using technology would be better and in some other groups using manipulative would work better. In this study we mostly used the manipulative.

Step 10. The stage of final assessment implementation and its effectiveness on identifying students' individual-learning differences: At this stage, the researcher should use a researcher-made mathematics test. The test was conducted in such a way that the time interval between teaching and post-teaching was considered in terms of the importance of the durability of the learned concepts.

4. Participants

The statistical population of the present study included the two educational centers of working children in Tehran (Molavi and Naser Khosrow Working children centers), where the working children (Afghan children) were trained from the first to the fourth elementary school levels at these centers. According to the available samples, the researchers randomly selected two groups from these two centers who were studying in the third grade of elementary school. The experimental group was trained through teaching based on the educational neuroscience strategies (23 male and female Afghan children aged between 9 to 11 years old) and the control group was trained through traditional teaching method (20 male and female Afghan children aged between 9-10 years).[4]

[4] The working children (Afghan children) had mostly discontinued their education due to the academic failure, dropout or the critical economic conditions; therefore, their age range might be higher than normal.

5. Instruments

In this study, two researcher-made tests (pre-test and post-test) were prepared based on the content of the third-grade elementary school level mathematical book, which was developed by the teachers / educators in the working children's educational centers, and according to the desired mathematical topic. These two tests were designed based on the standard tests of the education organization of Tehran city and based on the content validity verification with the Lawshe formula indicators in eight questions (each) and the total points was from 20. To test the reliability, two tests were implemented on a group of 25 students. The results during the procedure were shown to be higher than 0.7, which determines that the two tests were stable.

6. Findings

After collecting data when a traditional intervention and a new intervention were used in the control and experimental groups, respectively; in this section, we presented the descriptive statistics including central and dispersion indicators in Table 1 for each of the groups, which is as follows:

Table 1.
Descriptive statistics

Test type	Groups	Mean	Standard Deviation	Number
Pre-test	Control	10.16	2.03	20
	Experimental	10.79	2.29	23
Post-test	Control	11.77	2.15	20
	Experimental	14.02	1.96	23

As shown in Table 1, the mean of the post-tests is not equal between the two groups of control and experimental, after the use of intervention, and they are significantly different. In the inferential statistics section, one of the assumptions of ANCOVA test is the homogeneity analysis of the error variance, for which the Leven test was used and it was found that the P-value was greater than 0.05.

Table 2.
Tests of Between-Subjects Effects for homogeneity of the slope of regression

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Pre	91.896	1	91.896	45.058	0.000
Group	34.404	1	34.404	16.869	0.000
Error	81.580	40	2.040		
Total	7468.500	43			
a. R Squared = 0.64 (Adjusted R Squared = 0.62)					

Therefore, it can be claimed that the homogeneity condition of error variance is observed. The assumption of normal distribution of data (scores) is another assumption of covariance analysis. To test this case, K-S and SH-W tests were used, and since P-values were larger than 0.05, the condition of normality of data in the examination of both K-S and SH-W tests were observed. Therefore, the distribution of scores in variables is natural. The assumption of homogeneity of the slope of regression line is another assumption of variance analysis. To investigate this case, the interaction effect test was used and the result showed that P-values of the interaction effect of pre-test (overlap) of the (independent) group for the variables were larger than 0.05, therefore the assumption of homogeneity of the regression slopes is approved (See Table 2). Finally, the final results are shown in Table 3:

Table 3.
Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Pretest	91.89	1	91.89	45.05	0.000	0.53	1.000
Group	34.40	1	34.40	16.86	0.000	0.29	0.98
Error	81.58	40	2.04				
Total	7468.50	43					

According to the results of Table 3, the results of test of between-subjects (models) effects with regard to the pre-test scores as the auxiliary variables, the implementation of the educational neuroscience steps led to a significant difference between the control and experimental groups ($p<0.05$). Therefore, teaching based on educational neuroscience ($p<0.05$ and $F = 16.86$) with the Eta squared value of 53% is effective on the mathematical performance of working children, studying at third grade of elementary school.

7. Conclusion

Child labor and work of children in developing countries such as Iran has become a very common phenomenon. Child labor has always had its opponents in the whole world, and many countries are negotiating to reduce this phenomenon. Millions of children in the developing countries are engaged in working on streets such as peddling or doing other works to meet their basic needs. If children's working be due to their low training or very low levels of education, their economic future as well as their welfare in future will be at stake since future occupations require education and special skills while working children will not learn these skills in a timely manner, because of lack of adequate training and lack of education; therefore, their economic and social situation in the future will be at stake. Education is one of the most important means of generating income for the working children and getting them out of poverty and misery. Many empirical studies have shown that factors such as access to credits, quality of education and family characteristics, have been very effective in the education, and its implementation in children's decisions towards work or study. On the other hand, families that maximize their well-being or welfare might prevent their children from going to school and make them work, due to the poor quality of the schools or the high expenses of the education. Moreover, the environmental stresses at the place of residence and education (if they go to school) might be a challenge for every working child. The economic and critical conditions of Afghan children who came to Iran due to immigration and the escape from the war are not well organized, and most of them have academic failure, especially in the field of mathematical learning, since they do not have the time to practice the mathematical activities in a day or night. On the other hand, they are not motivated to attend the classrooms, specially the mathematics classes, because of living in difficult situation. To this end, the researcher sought a different strategy, distinguished from the current educational strategies. Using the teaching based on educational neuroscience strategies, working children in the third grade of elementary school were significantly able to outperform the use of traditional strategies in mathematical teaching. With these ten steps, the working children were able to classify their knowledge, recreate their prior knowledge in different situations, find logical reasons, and always exchange information with reference to the correct content. Moreover, it was observed that the working children (Afghans) were able to be active in the process of learning mathematical concepts and they maintained this activity, and therefore it was shown that teaching based on the ten steps of the educational neuroscience strategies was effective for them. The traditional teaching for such children was accompanied by the teacher's explanations in accordance with the content of the book. Subsequently, the teacher referred to the mathematical exercises and finally, the exercises had to be solved. In such a situation, working children were focused on mathematical activities to find the correct answer, and their only supporter was their teacher. No exchange of ideas and mathematical discoveries took place. In such an environment, a working child who lives in a difficult situation, at different time intervals will be reluctant to learn mathematics because all activities are dictated to him. In the ten steps related to the field of educational neuroscience, the researcher sought to take steps to improve brain functions and the step-by-step learning processes along with making working children create ideas. By employing educational neuroscience strategies-based educational management, learners outperform the use of traditional teaching models. Using this model, students can classify their information and knowledge, recognize their knowledge in different situations, follow a logical reason and always discuss documented. In addition, this model activates the students' minds from the beginning of teaching, and keeps them active until the end of teaching. As a result, educational neuroscience strategies-based educational management improves learning. Accordingly, it is suggested that teachers continue taking right steps in teaching based on educational neuroscience strategies, especially in mathematics and in using the neuroscience-based teaching steps, pay attention to the individual-learning differences of the working children to prevent their academic failure. It is also suggested that the educational neuroscience, based on the gender, functional, and cultural differences of working children should be implemented and compared.

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