World Transactions on Engineering and Technology Education
Vol.14, No.3, 2016

A kinaesthetic approach to teaching electrical engineering

Vesna Geršak†‡ & Gregor Geršak†

University of Ljubljana, Ljubljana, Slovenia†
University of Primorska, Koper, Slovenia‡

ABSTRACT: This article presents a pilot study of one of the holistic types of teaching, i.e. the kinaesthetic approach, to teach and learn complex topics at a university level. Lectures on two topics of second year electrical engineering laboratory exercises were conducted using the creative movement method. The control group of students was taught using the classic audio and visual ex-cathedra method. The experimental group was taught the same topics by means of the holistic kinaesthetic method. The groups were, then, compared using questionnaires, short written quizzes and written examinations. The results of the comparison indicate an improved understanding and better examination results within the experimental group, indicating that using holistic teaching methods is suitable and advisable even in higher education. The addition of holistic elements, such as creative movement, increased students' motivation and attention, and enhanced active engagement in learning, which resulted in improved learning.

INTRODUCTION

Throughout the history of educational philosophy, numerous authors, from John Dewey, Alice and David Kolb to Maria Montessori, stress the importance of using movement to promote learning. John Dewey attempted to dissolve the Cartesian dualism that separates the mind from the body. He *…celebrates* body-mind *as an essential unity in which mental life emerges from the body's more basic physical … functions* [1].

Movement awakens and activates many of our mental capacities [2]. The use of creative movement activities as a teaching method in school settings is an example of holistic teaching that integrates kinaesthetic and verbal activities. Holistic teaching could, in principle, be defined as a teaching (and learning) approach in which all human senses are activated by delivering new, additional and/or redundant information, not only by visual and audio channels, but also tactile and kinaesthetic channels and, in theory, also olfactory or even gustatory channels. Holistic learning means understanding with both the body and the mind [3].

Both kinaesthetic teaching and learning have been investigated by several researchers. Gardner recognised the importance of movement in learning in his Theory of Multiple Intelligences [4]. Bodily-kinaesthetic intelligence, as one of seven intelligences, was defined by Gardner as the *ability to solve problems or to fashion products using one's whole body, or parts of the body*. Recently, in cognitive science, the concepts of embodiment have been widely discussed, recognising a mutual dependence of the body and mind [5-12]. Embodiment refers to the fact that the brain is in the body, which in turn is embedded in a physical and social environment [13]. Davidson identifies the *deeply connected paths of knowing, where the body and mind intersect and become entangled* [14]. Embodied cognition reflects the argument that the motor system influences our cognition, just as the mind influences bodily actions. New discoveries have uncovered a wide range of interrelations between body postures and body movement, and perception, mental processing and action planning [13][15][16]. It should be imperative, therefore, that every student (from elementary school to university level) has the opportunity to learn in multiple ways, and has access to multivariate approaches. Bodily-kinaesthetic intelligence is still one of the most undervalued in the school system. Learning to include a student's moving body in the classroom requires making a significant shift in the teacher's conception of knowledge and teaching methods. Shapiro explains: *…Creative movement … offers a unique and powerful form of human expression. It allows us to speak in a language that is visceral and far less mediated by our thought and abstract conceptualisation. It provides, at times, a raw, embodied way of capturing human experience* [17].

The use of creative movement as a teaching method in educational settings is an example of holistic teaching and learning, where students use movement to express, form and create various educational content. This method encourages the student to learn, communicate and create through his/her body. When using creative movement, students develop in the intellectual, emotional, social, aesthetic, physical and psychomotor fields. Kinaesthetic learning stimulates students' understanding and creativity, improves interpersonal relationships, motoric and cognitive development in a positive way, creates positive emotional and social experiences, and causes the loosening of inner tensions. When students translate information from a linguistic to a kinaesthetic language they improve their own comprehension, expression, and application of science concepts. The results of various studies, where primary and secondary school children were involved in creative movement, show that cooperation between students improved, and that students were more easily motivated for various types of learning content [18-22]. This approach also brings the more complicated and less understandable concepts closer to students. Movement makes students feel pleasant, connecting them with positive emotions. Additionally, working in groups develops social skills. This type of climate contributes to better academic results and to longer lasting knowledge [18-21][23]. Creative movement is considered an important learning approach that helps students to connect abstract ideas to concrete and fundamental movement concepts [24].

A similar example is a well-known method for teaching language, called total physical response. The method is based on the coordination of language and physical movement, where students respond with whole-body actions [25]. Another methodology, where the expression of the body to music is used in the learning process, is convergent pedagogy [26]. Various studies have been published showing the effectiveness of using the kinaesthetic approach for teaching mathematics, physics, chemistry, technology and engineering to elementary and secondary school students, including topics like axial symmetry, geometry, electrical circuits and molecular structures [27-35]. The research on kinaesthetic teaching should not be limited to elementary and secondary school students, but should reach to the highest academic levels of graduate and postgraduate students as well [36].

This article describes a pilot study in which a holistic teaching and learning approach is used by including creative movement elements in lectures for undergraduate engineering students. The main hypothesis of the experiment was that using the kinaesthetic approach to teaching would improve students' motivation, understanding of the topics and cognition, and would contribute to better results in written examinations at the end of the semester.

METHODS

The study was conducted on a group of second-year electrical engineering students at the University of Ljubljana. In the study, from a total of 110 students, data were collected from 56 students. Of these, 41 students participated as the control group and 15 students as the experimental group.

At the University of Ljubljana, the Measurement Instrumentation course includes the basics of metrology, measuring methods and instrumentation [37][38]. The one-semester course is composed of two hours of lectures and two hours of laboratories every week. The students learn how to perform measurements using various methods and measuring instruments, and how to evaluate measuring results. Prior to the laboratory sessions, pre-laboratory lectures are given, describing in detail the goal of each exercise with practical guidelines for their implementation and samples of examination questions from this particular topic. The course concludes with a written and an oral examination. The written examination consists of five questions from the topics of electrical and magnetic measurements.

For this study, two pre-laboratory lectures were selected from the syllabus of the Measurement Instrumentation course: measuring the magnetic properties of ferromagnetic materials and RS-232 communication in measurement instrumentation. Two groups of students were taught by two lecturers who had similar teaching backgrounds and a similar approach to students, style of presenting, type of personality, and comparable results in the Annual University of Ljubljana Students' Opinion Survey. In order to minimise the differences in lectures and the amount of information given to the students, the two lecturers were instructed to lecture on agreed topics with the same theoretical background, focusing on the same main points of the exercise.

The lecturers used two different approaches to teach the students. The first group (the control group) had laboratory exercises explained to them with the classic audio and visual (pictorial and symbolic level) ex-cathedra method. The second group (the experimental group) was taught the same topics by means of kinaesthetic method. The differences between the groups were evaluated, focusing on the amount and quality of gained knowledge, and the social and emotional aspects of each method of teaching. At the end of the semester, the topics were included in the written examination. The differences between the groups' examination results were analysed.

The Pre-laboratory Lecture Topics

Two topics were selected for the experiment. In the first pre-laboratory lecture, the lecturer guided the students through the topic of measuring the magnetic properties of ferromagnetic materials. Only a couple of students were actively involved, while the others were observers. In the second pre-laboratory lecture, all the students were actively involved in the kinaesthetic presentation of RS-232 interface bus and communication protocol during measurement.

Guided Exercise – Measuring the Magnetic Properties of Ferromagnetic Materials

The first laboratory exercise included determining the BH curve of certain ferromagnetic material [39][40]. It was focused on the static BH magnetising curve, using the DC powering current and dynamic hysteresis with an AC powering current. In both static and dynamic conditions, powering the current into the primary windings generates magnetic flux, which is transferred via ferromagnetic material to the secondary windings, where voltage is induced.

In principle, the static BH magnetising curve of a ferromagnetic material can be determined by measuring magnetic flux density B and magnetic field strength H. By measuring the current going into the primary windings, the students could determine the value of H, and by measuring the time integral of induced voltage in the secondary windings, the value of B. Within the laboratory, the resulting hysteresis of the ferromagnetic core was determined by means of a virtual instrument, measuring the current and induced voltage and calculating the specific losses of the material.

The main goal of the kinaesthetic lecture was to help the students better understand the physics and the principles of measuring the B and H of the ferromagnetic material. Their understanding of the topic was expected to have improved and strengthened by moving through space and physically performing some of the activities of the electromagnetic quantities. Table 1 shows the steps of the guided exercise. The lecturer was highly involved in the process, i.e. preparing - drawing wires, windings, coils, ferromagnetic core on the floor, and thematically guiding the students through the circuit allowing them to draw conclusions for themselves.

Table 1: The steps to teaching the measuring of magnetic properties of ferromagnetic materials.

Step	Activity	Description
1	Current flowing through wire	The lecturer prepared a single wire by drawing a line on the floor (using duct tape). A student was selected and encouraged to represent the DC and AC currents in her/his own way.
2	Magnetic fields in an air-cored coil	The lecturer drew a coil. A discussion on generated magnetic flux density in an air-cored coil took place. Another student was selected, representing the generated magnetic flux, and presented the AC and DC magnetic flux densities and spatial distribution of the generated magnetic field.
3	Introducing a ferromagnetic core in the coil	The lecturer drew a ferromagnetic ring as the coil core. A discussion on the permeability of materials followed.
4	Secondary coil	The lecturer drew the secondary coil. A discussion about induced voltage in both static and dynamic conditions, and measuring methods followed. Another student was selected to represent the induced voltage.
5	Synchronisation of the phenomena	All three students worked in a synchronised way, following the student representing current. The BH curve of the ferromagnetic core was constructed from the current and the induced voltage.

Autonomously Performed Exercise - RS-232 Communication Protocol

In this laboratory exercise, the students were first presented common interface buses used for communication between a measuring instrument and a computer. The experiment was focused on the RS-232 communication protocol and its main features [41].

The lecturer introduced the protocol and basics of standard commands for programmable instruments (SCPI), i.e. the standard for syntax and commands to use in controlling programmable measuring devices and ASCII coding [41]. The RS-232 explanation was not detailed; instead, the protocol was just briefly introduced. A couple of students were, then, selected to explain the property and purpose of each bit within a SCPI command according to the RS-232 protocol.

The students themselves had to decide on a binary coding - what kind of body gesture/posture will stand for logical *1* and what kind for logical *0*. The lecturer also performed parts of his explanations kinaesthetically, i.e. he explained the RS-232 voltage levels by standing on his head. Thus, kinaesthetically indicating, that in the RS-232 protocol logical *1* is represented by a negative and logical *0* is represented by positive voltage level, the opposite of what one would expect.

Information transfer concepts, such as baud rate or parity, were explained by selecting a group of students representing a byte of information and moving from the *personal computer* (one end of the corridor outside the classroom) to the *measuring instrument* (the other end of the corridor) at different speeds, thus, explaining the baud rate.

After this kinaesthetic explanation, all the students were divided into groups of five. The groups of students were selected in such a way that each student represented a byte of information (11 bits), thus, coding one letter of the five-letter SCPI command. Each group received a randomly selected SCPI command and created a choreography that corresponded to the SCPI command. They were using their own (arbitrary) form of representing bits of the logical *0* and *1*.

Additionally, to make the exercise more fun and motivating, three students were selected to decode each bit of information into the SCPI command. If the coding produced the wrong results, the lecturer would draw attention to the mistake, as in information transfer error issues (e.g. parity concepts) or baud rate (the students were performing their movements faster or slower).

Group Comparison

Three comparisons were performed: the answers to a short quiz on the topics, the answers to a questionnaire on the teaching approach and the score of the relevant question in the final examination.

At the end of each lecture, short anonymous questionnaires were filled in by the students. The questionnaires included a short written quiz, which contained four specific questions on the topics of laboratory, i.e. measuring the magnetic properties, e.g. about specific losses of magnetic material, plastic coil-core and RS-232 communication protocol, e.g. *RST command, voltage level of USB protocol, parity, baud rate. Additionally, the students filled in questions about the teaching approach itself (Table 2).

Table 2: The questionnaire about the teaching method for the experimental and control groups.

Experimental group	Control group	Answers
How interesting did you find the teaching of this topic?	How interesting did you find the teaching of this topic?	Ordinal scale from 1 (not at all) to 5 (very much).
How would you rate your understanding of the laboratory exercise?	How would you rate your understanding of the laboratory exercises?	
Would you like to have more lectures like this?		
What was your general feeling during this class?	What was your general feeling during this class?	
Why?	Why?	Descriptive

Both topics were included as a question in the written examination at the end of semester, e.g. a question where the students had to present the time dependence of the voltage levels for a single character RS-232 transfer. In the analysis of the examination results, students' answers were graded from 0 (completely wrong answer) to 10 points (completely correct answer), and the answers of the experimental and control groups were compared. Equal variances were not assumed; therefore, Welch's *t*-test was used for comparison. The results were evaluated using the SPSS Statistics 20 statistical program (by IBM Corporation, USA), using the independent sample *t*-test for equality of means.

RESULTS

The holistic approach to teaching electrical engineering at university level provided some interesting outcomes. The students were very imaginative when it came to representing the concepts in their own way. The innovative solutions were amazing. One such example was the representation of the low-pass filtering of high-induced voltage impulses, occurring when the DC powering current into the primary winding was commutated. One student represented the induced voltage impulse by jumping high in the air. Another student, representing the low-pass filter, did not allow the first student to jump high by forcing him to the ground (Figure 1 left); thus, representing the attenuation of the induced voltage amplitude.

During the guided teaching of measuring ferromagnetic materials, they contrived a variety of representations of AC or DC currents (e.g. walking steadily along the wires for DC and spinning around for AC current), the resulting AC or DC magnetic flux (e.g. time synchronised steady walk along the ferromagnetic core for DC or rotating their hands for AC flux, with their hands raised for high flux amplitudes with a high permeability core or lowered for a low permeability core), the induced voltage shape (e.g. high jumps for the voltage impulse or twisted arms for AC induced voltage), etc.

Figure 1: Left - action in the corridor - filtering the induced voltage pulse (encircled). Middle and right - two logical states of the RS-232 protocol presented by a student.

Within the RS-232 protocol exercise, some examples of the bit representation included hands down and hands up for *0* and *1*, respectively, or standing for *0* and sitting for *1*, various forms of jumping (Figure 1 middle and right), opening or closing the eyes, touching their noses for logical *0* and ears for logical *1*, etc. Some of the students used additional materials, such as a roll of paper (turned vertically for logical *1* and horizontally for *0*) or an apple (shown for *1* and hidden behind their back for *0*). In general, the students thought of a clearly distinguishable binary representation of the logical levels, which they performed with their bodies and, especially, with alternated physical quantities (e.g. AC current), with their body movements.

Most of the students involved were very cooperative and enjoyed taking part in this type of an educational process. When the questionnaires were analysed, personal opinions and notes were also checked and compared (Table 3). The questionnaire being anonymous and writing personal opinions not obligatory, it was expected that there would not be many of them. In fact, the control group did not include many comments and opinions (six out of 41 or 15%), while 12 out of 15 students (80%) of the experimental group included their personal views on the teaching and learning approach. This points to the conclusion that they liked the lecture.

Table 3: A qualitative comparison - opinions of the students involved.

Control group	Experimental group
It was boring. Monotonous. Uninteresting material and interpretation. Drawn and lengthy explanations.	More interesting, dynamic and not monotonous. Very different approach in terms of other classes. More fun than sitting. I laughed and enjoyed the show. Very relaxed atmosphere. More interesting and more active. Interactive and easier to remember. We did not have to absorb a lot of information in a short time.
	This is not the best way of explaining such topics. I am introverted, I did not like it (but it was fun watching the others).

Figure 2 shows a comparison of the general questions about teaching from Table 2. The answers to general questions about the teaching approach were analysed for two experiments. After the first kinaesthetic lecture, the average answer to the question *whether they would like to have more lectures like this* was 3.9 (SD = 1.1). After the second kinaesthetic lecture, it even increased to 4.3 (0.8). Therefore, one could conclude that the majority of the students enjoyed this type of teaching and learning and would like to experience it in the future.

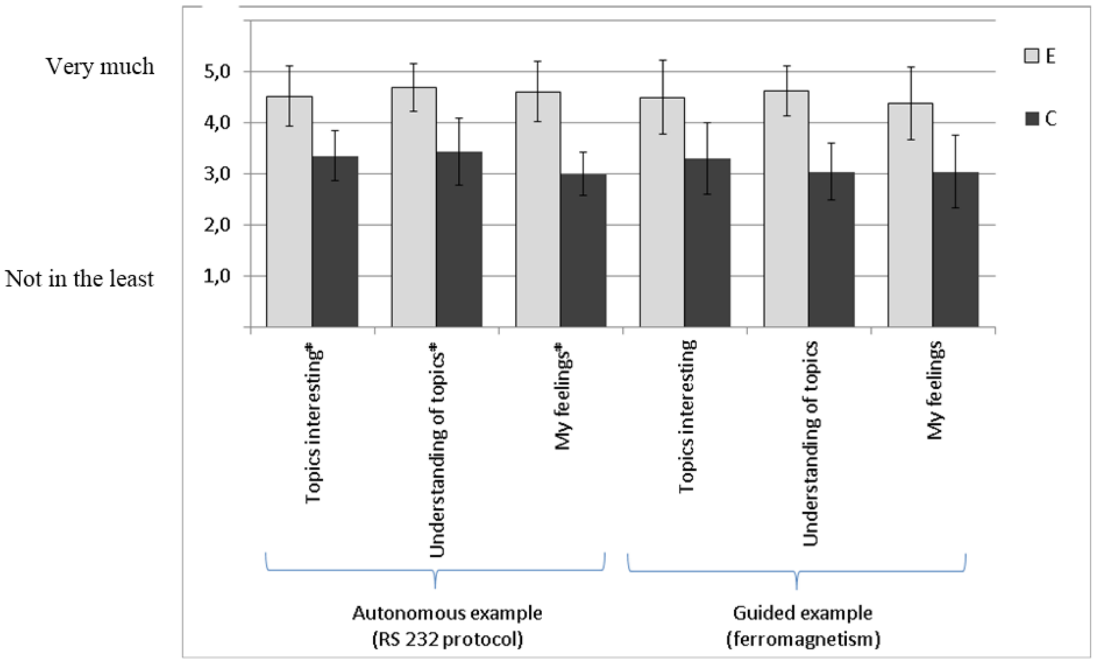

Figure 2: A comparison of the control (C) and the experimental (E) group answers (not in the least - 1) to (very much - 5), ordinal scale, to the general questions about the teaching approach for two topics (guided example and autonomous example). Error bars represent the standard deviation of answers. * indicates a statistically significant difference between groups ($p < 0.05$).

An analysis of the answers to specific questions from the control and the experimental groups is shown in Table 4. In general, the control group had more wrong or missing answers than the experimental group.

Table 4. A comparison of the control and the experimental groups answers to specific questions from the short quiz on the topics of the laboratory exercises. The bold font indicates a statistically significant difference between groups ($p < 0.05$).

Specific question on	*t*	*p*
Autonomous example (RS-232 protocol)		
Voltage level of RS-232 protocol	$t(22.00) = 8.899$	0.000
Voltage level of USB protocol	$t(22.00) = 1.447$	0.162
Parity	$t(22.00) = 4.114$	0.000
Baud rate	$t(22.00) = 3.166$	0.004
SCPI reset command	$t(34.22) = 9.841$	0.000
Guided example (ferromagnetism)		
AC current induced voltage	$t(22.00) = 2.152$	0.043
DC current induced voltage	$t(22.00) = 2.787$	0.011
Plastic coil-core	$t(22.00) = 1.447$	0.162

The comparison of the written examination answers from the experimental group (n = 15) and the classically taught students (n = 41) showed a statistically significant difference in their answers on the topic of measuring ferromagnetic materials. Of the 10 maximum points, the experimental students scored on average 9.5 (SD = 1.0) points, whereas the control group scored 5.8 (SD = 4.4), $t(19) = 3.217$, $p = 0.004$. The difference between answers on the RS 232 protocol was smaller and did not reach a statistical significance: the experimental group scored 8.0 (1.5) points and the control group 7.0 (2.7) points, $t(45) = 1.640$, $p = 0.108$. Therefore, one could conclude that in the written examinations the experimental group did better compared with the control group.

DISCUSSION

This experiment was a pilot experiment dealing with a holistic didactic approach, based on the latest findings in neuroscience (embodiment) and various teaching and learning approaches/methods. The kinaesthetic approach, a type of active learning [42], was used to teach an experimental group of engineering students. The control group was taught using the classic ex-cathedra teaching. The experiment comprised of two exercises. During the first exercise, the lecturer guided the students. In the second, autonomously performed exercise, the students used their own creativity and came up with their own movements to express their knowledge about the topic. In both exercises, the students had to translate their knowledge into kinaesthetic learning, by which they strengthened their understanding of the topic.

The experiment showed that even engineering students were quite capable of expressing themselves using movement and were happy to participate. The results of this pilot study indicate an increase in the students’ motivation, and the possibility of better explanation and understanding. The students used their bodies to structure what they thought about the topic. This type of teaching proved to be a valuable tool for a teacher of undergraduate electrical engineering. The RS-232 topic was better accepted than ferromagnetism, which one can associate with the fact that all of the students were actively involved.

One of the positive sides of kinaesthetic teaching was its social aspect. During the lesson, the students self-organised into groups, interacted strongly and discussed the topics, thus, being actively involved in the task. In fact, they were so active that the goal subjects of the lecture, i.e. magnetic properties and the RS-232 protocol, were not even perceived as something they had to learn. They used this goal as a starting point, which helped them to be creative, and think of different ways of showing the basics of magnetic measurements and the RS-232 protocol. It was a foundation for the creative development of their commentaries and enabled them to combine different skills and knowledge. The majority of them simply enjoyed the lecture and took part in it. They had fun, and were more relaxed and more focused on the topics. They learned the basics of the magnetic measurements and communication protocol with ease, without being aware of the learning process.

There are certain shortcomings of this pilot study that should be noted. To achieve a firmer statistical relevance, a higher number of participants is necessary. The main challenge was to distinguish clearly between the learning effect due to the kinaesthetic approach or due to higher motivation and attention because of the students’ perceived novelty of the teaching/learning style. Due to the complexity of the cause-effect relationship, the conclusion of this study can only be confirmation that the increased motivation and attention improved the learning results of the students. The study indicated that one of the ways to increase motivation and the attention is the employment of holistic types of teaching, in this case creative movement. Additionally, the influence of different lecturers (personality, style of presenting and explaining, personal characteristics, etc.) could be expected. In the future, to obviate this, it is planned that a single lecturer will give lectures to both groups, control and experimental. Another possibility would be the randomisation of teacher-group pairs. Yet another improvement would be to elicit the students’ opinion on the teaching, i.e. what they actually learned and why they did what they did, by using a qualitative analysis in the form of an interview, thematic analysis and coding technique.

Based on the results of this study, another kinaesthetic lecture is being prepared. One of the topics, which is important in measuring science and usually also quite difficult to grasp for second year students, is the concept of measuring uncertainty [38]. Students will be invited to search for the major uncertainty contributions of a measurement and, afterwards, represent them kinaesthetically, with the main goal of geometrically summing the contributions and identifying the largest contributions and, finally, to find methods and procedures to lessen these.

CONCLUSIONS

This pilot experiment compared two groups of students; each taught certain topics using different teaching approaches: the kinaesthetic approach and the classical ex-cathedra teaching method. The results of a comparison indicated differences. The quantitative comparison showed that the experimental group gained a better understanding for the majority of the short quiz questions and had more correct answers compared with the control group.

The results of the written examinations indicated that the experimental group was significantly more successful at one topic compared with the control group. The qualitative comparison showed that the experimental group was more motivated and more eager to be a part of the learning process and, in general, enjoyed and profited from the lectures more.

ACKNOWLEDGMENT

The authors wish to express their gratitude for the comments and professional support to Susan Griss of Minds in Motion, one of the pioneers of kinaesthetic education and creative movement teaching method.

REFERENCES

1. Schusterman, R., *Body Consciousness: A Philosophy of Mindfulness and Somaesthetics*. New York, NY: Cambridge University Press (2008).
2. Hannaford, C., *Smart Moves: Why Learning is not All in Your Head*. Salt Lake City, UT: Great River Books (2005).
3. Kroflič, B., *Creative Movement - the Third Dimension of Teaching*. Ljubljana, Slovenia: Znanstveno in Publicistično Središče (1999) (in Slovenian).
4. Gardner, H., *Frames of Mind: the Theory of Multiple Intelligences*. New York: Basic Books (1983).
5. Gibbs, R.W., *Embodiment and Cognitive Science.* Cambridge: Cambridge University Press (2005).
6. Lindgren, R. and Johnson-Glenberg, M., Emboldened by embodiment: six precepts for research on embodied learning and mixed reality. *Educational Researcher*, 42, **8**, 445-452 (2013).
7. Sousa, D.A., Mind, brain, and education: the impact of educational neuroscience on the science of teaching. *LEARNing Landscapes*, 5, **1**, 37-43 (2011).
8. Rinne, L., Gregory, E., Yarmolinskaya, J. and Hardiman, M., Why arts integration improves long-term retention of content. *Mind, Brain, and Educ.*, 5, **2**, 89-96 (2011).
9. Fink, A., Graif, B. and Neubauer, A.C., Brain correlates underlying creative thinking: EEG alpha activity in professional versus novice dancers. *Neuroimage*, 46, 854-862 (2009).
10. Thompson, E., *Mind in Life: Biology, Phenomenology and the Sciences of Mind*. Cambridge, MA: Belknap Press (2007).
11. Katz, M. (Ed), *Moving ideas: Multimodality and Embodied Learning in Communities and Schools*. New York, NY: Peter Lang (2013).
12. Osgood-Campbell, E., Investigating the educational implications of embodied cognition: a model interdisciplinary inquiry in mind, brain, and education curricula. *Mind, Brain, and Educ.*, 9, **1**, 3-9 (2015).
13. Hommel, B., Müsseler, J., Aschersleben, G. and Prinz, W., The theory of event coding (TEC): a framework for perception and action planning. *Behavioral and Brain Sciences*, 24, **5**, 849-878 (2001).
14. Davidson, J., *Embodied Knowledge: Possibilities and Constrains in Arts Education and Curriculum*. In: Bresler, L. (Ed), Knowing Bodies, Moving Minds: towards Embodied Teaching and Learning. Dordrecht, the Netherlands: Kluwer Academic Publishing, 197-211 (2004).
15. Hoffman, J., Stoecker, C. and Kunde, W., Anticipatory control of actions. *Inter. J. of Sports and Exercise Psychology*, 2, **4**, 346-361 (2004).
16. Koch, I., Keller, P. and Prinz, W., The ideomotor approach to action control: Implications for skilled performance. *Inter. J. of Sports and Exercise Psychology*, 2, **4**, 362-372 (2004).
17. Shapiro, S.B., *Dance in a World of Change: Reflection on Globalization and Cultural Difference*. Champaign, IL: Human Kinetics (2008).
18. Kroflič, B., The effects of creative movement as a teaching method on children's creative thinking. *Educ. Able Child*., 6, **1**, 6-13 (2002).
19. Griss, S., Everybody, stand up! The power of kinaesthetic teaching and learning. *Independent Teacher*, 10, **2**, (2013), 13 September 2015, http://www.nais.org/Magazines-Newsletters/ITMagazine/Pages/Everybody-Stand-Up.aspx
20. Skoning, S.N., Movement and dance in the inclusive classroom. *Teaching Exceptional Children Plus*, 4, **6**, (2008), 13 September 2015, http://files.eric.ed.gov/fulltext/EJ967723.pdf
21. BenZion, G., *Overcoming the Dyslexia Barrier: the Role of Kinaesthetic Stimuli in the Teaching of Spelling*. In: Blasing, B., Puttke, M. and Schack, T. (Eds), The Neurocognition of Dance: Mind, Movement and Motor Skills. New York: Psychology Press, 123-133 (2012).

22. Anttila, E., *Dance as Embodied Dialogue*. In: Svendler Nielsen, C. and Burridge, S. (Eds), Dance Education around the World: Perspectives on Dance, Young People and Change. London and New York: Routledge, 79-87 (2015).
23. Geršak, V., Thinking through movement and dance: creative movement as a teaching approach in Slovenian primary schools. *Taiwan Dance Research J.*, 9, 19-39 (2014).
24. Overby, L.Y., *Student Reflection: The impact of Dance Integration.* In: Overby, L.Y. and Lepczyk, B. (Eds), Dance: Current Selected Research, 8, New York: AMS Press, 183-202 (2015).
25. Asher, J.J., *Learning another Language through Actions: the Complete Teacher's Guidebook*. California: Sky Oak Production (1977).
26. Wambach, M., *Convergent Pedagogy*. Brussels, Belgium: Centre International Audio-Visuel pour l'Education et la Recherche (CIAVER) (1995).
27. Aubusson, P., Fogwill, S., Barr, R. and Perkovic, L., What happens when students do simulation-role-play in science? *Research in Science Educ.*, 27, **4**, 565-579 (1997).
28. Hohl, D.M. and Smith, D.M., *Ben Gay and Brownies: a Study of the Movement Experience and how it Affects Instruction in Elementary Mathematics*. Golden Valley, MN: Minnesota Center for Arts Education (1996).
29. Zurc, J. and Cotič, M., Role of movement in early teaching of mathematics. *Mat. šol.*, 11, **3-4**, 142-154 (2004) (in Slovenian).
30. Žagar, S., Creative movement as a method of teaching math. *Proc. 4th Inter. Symp. Child in Motion*, Koper, Slovenia: Science and Research Centre, University of Primorska (2006) (in Slovenian).
31. Lerman, Z., Chemistry: an inspiration for theatre and dance. *Chemical Educ. Inter.*, 6, **1** (2005), 13 September 2015, http://media.iupac.org/publications/cei/vol6/11_Lerman.pdf
32. Root-Bernstein, M.M., Lownds, N., Miller, J., Newman, D., Bristow, C., Overby, L. and Root-Bernstein, R.S., Body thinking beyond dance: connections to science. merging worlds: dance, education, society and politics. *Proc. The National Dance Educ. Organization 6th Annual Conf.*, CD-ROM, 20-24 October 2004, 354-369 (2004).
33. Root-Bernstein, M.M. and Root-Bernstein, R.S., Body thinking beyond dance: a tool for thinking approach. *Dance: Current Selected Research*, 5, 173-202 (2005).
34. Lujan, H.L. and DiCarlo, S.E., First-year medical students prefer multiple learning styles. *Advances in Physiol. Educ.*, 30, 13-16 (2006).
35. Alibali M. and Nathan, M., Embodiment in mathematics teaching and learning. Evidence from learners' and teachers' gestures. *J. of Learning Sciences*, 21, 247-286 (2012).
36. Bohannon, J., Dance Your PhD: and The Winner Is.... (2012), 13 January 2016, http://www.sciencemag.org/news/2012/10/dance-your-phd-and-winner
37. BIPM, International Vocabulary of Metrology - Basic and General Concepts and Associated Terms (VIM) (2008), 13 September 2015, http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2008.pdf
38. ISO, Guide to Expression of Uncertainty in Measurement. Geneva, Switzerland: ISO (1995).
39. Fiorillo, F., *Characterization and Measurement of Magnetic Materials (Electromagnetism)*. New York: Academic Press, (2005).
40. Tumanski, S., *Handbook of Magnetic Measurements*. New York: CRC Press (2011).
41. Horowitz, P. and Winfield H., *The Art of Electronics.* (2nd Edn), Cambridge, England: Cambridge University Press. 723-726 (1989).
42. Kolb, K., *Experimental Learning: Experiences the Source of Learning and Development*. London: Kogan, (1984).