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COVER PAGE

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Passig, David (2001) A taxonomy of ICT mediated future thinking skills. In Taylor, H. and Hogenbirk, P. (2001) *Information and Communication Technologies in Education: The School of the Future*. Kluwer Academic Publishers, Boston, pp 103-112

Passig, David (2007) Melioration as a Higher Thinking Skill of Future Intelligence. *Teachers College Record*. In print. Accepted 18.4.2005. Scheduled For Publication In: volume 109 #1 (Jan 2007).

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Innovative Combinations' Test: A Tool for Measuring the Melioration Skill

STRUCTURED ABSTRACT

Background

Earlier publications (Passig 2000, 2001, 2007) traced the basic nature of future society and proposed a relevant taxonomy of future cognitive skills that would provide our students with appropriate tools to succeed in the future. We have used Bloom's taxonomy as a working ground and expanded his categories to reflect the needs of the future. We have also suggested an additional cognitive category named *melioration*, which we believe, is not addressed in today's curriculum.

Purpose

Since there was no testing tool with which one could measure the *melioration* skill, we engaged in developing such a tool. This paper delineates the rational behind it, its structure and reliability.

Research design

The tool which we named The Innovative Combinations' Test (ICT) aimed at examining the student's ability to meliorate ideas. The training program which we developed for the purpose of validating this tool was named Thinking-Different. This training program was developed with an online interface named WebQuest. The training program's goal was to engage the participants in creating combinations of a variety of pieces of information and generate new ideas in solving ill-defined problems.

In order to validate the test we built two parallel versions. Both versions were shown to three experts that affirmed that the test indeed examines the ability to make combinations of disparate ideas, i.e., *melioration*.

The reliability of the test was examined via the parallel forms method. First, we sampled 54 6^{th} graders in a pilot study where they received two mixed versions of the test with a rotated order of the items. In the pilot study, a t test was applied to the data and no statistically significant differences were found between the two versions.

In order to determine the internal consistency of each version, *Cronbach's α* was calculated. We found a reliability of α=.81 and α= .77 for versions A and B, respectively.

In our study version A was administered before the training program and version B after the training program. The internal consistency test was administered to 60 other students. In version A we found a reliability of *Cronbach's α*=.81. In version B we found a reliability of *Cronbach's α*=.79 .

Conclusion

The Innovative Combinations' Test (ICT) could provide the teacher with a tool with which one could examine progress in the students' ability to meliorate information. The importance of this measuring tool stems from the need to prepare students for tomorrow's world.

EXECUTIVE SUMMARY

This paper reports on the development of a tool for measuring the skill of *melioration*. The *melioration* skill was suggested as the seventh category in the taxonomy of future cognitive skills. This taxonomy has futurized the taxonomy of Bloom *et al*. *Melioration* is defined as the skill of selecting the appropriate combination of information and applying it to the solution of problems as they appear in different situations, times and places, thereby improving the combination. This skill assists in making complex adaptations between disparate ideas in real time, in the process of generating new ideas.

Three behavioral terms have been identified to be included in the *melioration* skill:

- Adaptation - The person creates an innovative product via the process of making a personal cognitive connection between two disparate fields.
- Connotation - The person connects items of personal significance of which he is aware, and is able, based on those items, to carry out an adaptation between two disparate fields.
- The Courage to Forget - The person is prepared to divest himself of conceptions, theories, or of situations which rigidify new thinking.

Two kinds of *melioration* of ideas were identified: *Melioration* of ideas which lead to improved sophisticated tools, and *melioration* of tools that give birth to new ideas which influence mankind.

The *melioration* of an idea can be demonstrated through the concept of Emotional Intelligence .Two unrelated concepts—intelligence and emotion—produce a new definition for a concept which provides a better explanation of a social, organizational, and managerial situation in a complex world.

The *melioration* of tools can be demonstrated through the concept of molecular-computers. The purpose of computers is to work with bytes of information. Since a byte of information has no size as such, we aspire to make the computer as small as possible. The day is not far away when we will develop a molecular size computer which will become a tool at the disposal of our sciences. This molecular computer will be much smaller, more efficient, and capable as any small machine, when compared with the human mind, which is relatively massive, and which loses and/or adds cells every day.

Melioration is a skill which has just been defined, and for which, as yet, measuring tools have not been developed. We engaged in developing a test, which we called the

Innovative Combinations' Test (ICT), which has two parallel versions. Following is a description of the training program and the validating process.

Age group

We have involved, in the process of validating the ICT tool, sixty school children. All were from a large urban area with a median socio-economic background. The participants were sixth and seventh grade pupils aged 11 and 12 years. These students were given, in a quasi-experiment of two months, a computerized training course to help them develop the skill in order to test it before and after the intervention.

Training Program

The training program which we developed for the purpose of validating our *melioration* skill measuring tool was named Thinking-Different. This training program was developed with an online interface named WebQuest. It is a computerized tool which can be used for developing a learning environment of the sort which enables the student to browse Internet sites, and research a range of subjects through challenging tasks. Studies have found that WebQuest encourages the development of higher-order-thinking skills in a problem solving environment.

The training program's goal was to engage the participants in creating combinations of a variety of pieces of information and generate new ideas in solving ill-defined problems. It challenged the participants to collect written, visual, and audio resources from the Internet. The resources could have been linked to form a web of connections. The participants collected materials and formed links according to specific tasks. For example, they were asked to surf virtual galleries displaying art works on a broad range of subjects quite removed, from each other. While looking at the different pictures, the students were asked to identify special elements and connect them in order to solve a problem that was introduced to them.

The Innovative Combinations Test

The Innovative Combinations' Test (ICT) aimed at examining the student's ability to meliorate ideas. We hypothesized that after taking the course titled "Thinking Different" the student would be able to better solve ill-defined problems. We therefore developed two versions of the test, one version was administered before the course and the second after the student took the course. The same tasks with minor nuances appeared in both versions.

The Innovative Combinations' tool was designed to measure the student's ability to solve real-life problems. Therefore, the starting point on each item of the test was a familiar daily life situation such as: A bus trip, a shopping situation in a supermarket, etc.

Real-life situations were situations to which technology has a great impact. For each situation a problem was introduced, where two random basic assumptions were presented. These basic assumptions stem from different fields of knowledge far removed from each other.

In designing the measuring tool we created an artificial situation which brought the realm of human knowledge close to the student through two basic assumptions: a. In real-life we more or less rely on scraps of information for the creation of combinations which can help us solve our problems; b. in our daily-life we choose for ourselves the bits of information from which we create the combinations in order to solve our problems.

Ten life situations were chosen in both versions of the two tests .Scoring the items of the tool was also based on the behavioral objectives of the *melioration* skill: Consonance, Connotation and Courage to disregard.

Every relevant idea which was drafted by a student was scored in a scale of 0-4

- 0 - If no combination was created, or if the one created wasn't relevant to solve the problem.
- 1 - If a combination of bits of information was created which reflects a personal connotation, but which has no correlation with the offered assumptions.
- 2 - If a combination was created which reflects a correlation between the offered assumptions and a personal connotation.
- 3 - If a combination was created which reflects the courage to forget, but which has no correlation with the offered assumptions.
- 4 - If a combination was created which reflects a correlation between the offered assumptions, the personal connotation, and the courage to forget

The student's final grade in the Innovative Combinations' Test was the sum of points collected in all 10 items. This sum reflects the level of his ability to meliorate ideas (40 points would be considered 100%).

Validating the Innovative Combinations' Test (ICT)

In order to validate the test we built two parallel versions which served as the pre and post-training ability to meliorate ideas. Both versions were shown to three experts—professors in leading universities specializing in cognitive studies, all three experts affirmed

that the test indeed examines the ability to make combinations of disparate ideas, i.e., *melioration*.

The reliability of the test was examined via the parallel forms method. First, we sampled 54 6th graders in a pilot study where they received two mixed versions of the test with a rotated order of the items. In the pilot study, a t test was applied to the data and no statistically significant differences were found between the two versions.

In order to determine the internal consistency of each version, *Cronbach's α* was calculated for both versions of the test. We found a reliability of α=.81 and α= .77 for versions A and B, respectively.

In our study version A was administered before the training program and version B after the training program since no significant difference was found between the versions in our pilot study. The internal consistency test was administered to 60 other students. In version A we found a reliability of *Cronbach's α*=.81. In version B we found a reliability of *Cronbach's α*=.79.

Summary

The *melioration* skill that reflects the ability to solve ill-defined problems makes it possible to enlarge the student's toolkit for high-order thinking skills. This skill opens the opportunity to employ the language of innovation in learning processes. With it students would be able to cope successfully with complex real-life problems and generate solutions with resources at hand.

The Innovative Combinations' Test (ICT) in this initial form aimed at providing the teacher with a tool with which one could examine progress in the students' ability to meliorate information. The importance of this measuring tool stems from the need to prepare students for tomorrow's world. It will be a world which will demand flexible, innovative thinking based on the fragmented human drifting and chaotic info-sphere. We hope that this initial version of the ICT would open the path to curriculum planners and educators to better design learning experiences that would reflect the genuine needs of our alumni.

Innovative Combinations' Test: A Tool for Measuring the Melioration Skill

Abstract

An adult must cope in his daily life with well-defined and ill-defined problems (Newell & Simon 1972). A well-defined problem has a clear path to a solution—a pre-set algorithm attuned to the desired solution located in the Problem Arena. An ill-defined problem has no clear solution. An ill-defined problem demands a sophisticated search in the realm of human information—a search which includes a multitude of alternative pathways. This set of problems requires a search conducted according to a heuristic search strategy. These include informal, intuitive, and speculative strategies which leads a person to the point where he finds the solution on his own. The *melioration* skill (Passig, 2007) can be categorized as a heuristic strategy for the solving of ill-defined problems.

Melioration is defined as the skill of selecting the appropriate combination of information and applying it to the solution of problems as they appear in different situations, times and places, thereby improving the combination (Passig 2001, 2007). This skill assists in making complex adaptations between disparate ideas in real time, in the process of generating new ideas.

This paper reports on the development of a tool for measuring the *melioration* skill. In order to examine the presence and improve the skill of *melioration*, we developed a test which we call the “Innovative Combinations' Test” which has two parallel versions. It has been validated with a group of sixty—sixth and seventh grade students in Israel. These students were given, in a quasi-experiment of two months, a computerized training course to help them develop the skill in order to test it before and after the intervention.

The test was found valid in a three stage process: a. face-validity among experts; b. reliability of parallel forms in an earlier study (α=.81 and α= .77 for versions A and B, respectively); and c. through *Cronbach's alpha reliability* before and after training (α=.81 and α= .79 for versions A and B, respectively). The results indicate that the Innovative Combinations' Test (ICT) is valid and reliable.

Keywords: Melioration, ill-defined problem, high order thinking skills

Introduction

Most teaching processes are geared toward teaching students how to find "the right answer." Most students will, by the time they finish their undergraduate studies, pass thousands of quizzes and examinations which test their knowledge and skills. This situation is not natural for an adult who must cope with two kinds of problems in his daily life—well-defined and ill-defined problems (Newell & Simon 1972). A well-defined problem has a clear path to a solution—a pre-set algorithm attuned to the desired solution located in the problem arena. An ill-defined problem, on the other hand has no clear solution. An ill-defined problem demands a sophisticated search in the realm of human information—a search which includes a multitude of alternative pathways. This set of problems requires a search conducted according to a heuristic search strategy. These include informal, intuitive, and speculative strategies which leads a person to the point where he finds the solution on his own. The *melioration* skill can be categorized as a heuristic strategy for the solving of ill-defined problems.

The *melioration* skill was most recently defined (Passig, 2007) as a skill of the future which is rarely, if ever, taught in school. It was suggested as the seventh category in the taxonomy of future cognitive skills (Passig, 2000, 2001). This taxonomy has futurized the

taxonomy of Bloom *et al*. (1956), and was based on studies which surveyed future developments in society, economy, and sciences. We have found that each of the six cognitive categories which Bloom formulated might have a new aspect which reflects an alumnus's future needs. On top of Bloom's six categories, the futurized taxonomy has added a seventh category, which was named *melioration*. Three behavioral terms have been identified to be included in the *melioration* skill (Passig, 2007):

- Adaptation – The person creates an innovative product via the process of making a personal cognitive connection between two disparate fields.
- Connotation – The person connects items of personal significance of which he is aware, and is able, based on those items, to carry out an adaptation between two disparate fields.
- The Courage to Forget – The person is prepared to divest himself of conceptions, theories, or of situations which rigidify new thinking.

Two kinds of *melioration* of ideas were identified: melioration of ideas which lead to improved sophisticated tools, and melioration of tools that give birth to new ideas which influence mankind.

The melioration of an idea can be demonstrated through the concept of Emotional Intelligence (Goleman, 1995). This term brings about a better understanding of human intelligence. Two unrelated concepts—intelligence and emotion—produce a new definition for a concept which provides a better explanation of a social, organizational, and managerial situation in a complex world.

The melioration of tools can be demonstrated through the concept of molecular-computers, as discussed by Regis (1995). According to Regis, the purpose of computers is to work with bytes of information. Since a byte of information has no size as such, we aspire to make the computer, which deals with it, as small as possible. On the other hand, the smallest component part of anything known to man is the molecule. Biology has introduced us to

complex, organized systems of molecules. Regis predicts that the day is not far away when we will develop a molecular size computer which will become a tool at the disposal of our sciences. This molecular computer will certainly be different from the brain in that it will be mechanical and not biological. It will also be much smaller, more efficient, and capable as any small machine, when compared with the human mind, which is relatively massive, and which loses and/or adds cells every day. The unrelated concepts of tools—computers and molecules, could merge to develop a new kind of tool that ultimately would enable humans to further develop ideas.

Initiating this line of thought, Eric Drexler (1992), then a student at MIT and now the Head of the Foresight Institute for the Study of Nanotechnology in California, had the idea of taking biological components and metaphorically "convincing" them to do things for us, as they do in nature. His idea was to put nature's components together in a new way in order to get a different overall arrangement. What he is suggesting is not merely a laboratory arrangement of known biological structures but an arrangement not seen in any natural serial structures of atoms and molecules.

The innovation in Drexler's idea is that these tools could push the cells to produce something of a completely new kind, as opposed to creating merely artificial versions of things that already exist. The idea of arranging building blocks of nature in a different manner is an example of the fusion of mechanical engineering and molecular biology to create a new science which meliorates both realms of science. This provides us with a new, meliorated tool with which we could work in ways that were unimaginable before.

Melioration is a skill which has just been defined, and for which, as yet, measuring tools have not been developed. One tool which may be close to fitting that role was found in a survey of the literature. It is called RAT – Remote Associates Test (Mednick & Mednick, 1967). The Mednicks maintain that the process of creative thinking involves making new

associative connections between different elements, and that the further one element is from the other, the more creative the process. They believe that the creative person has a proclivity for putting disparate elements together into new and more efficient combinations. In order to measure interpersonal differences, they proposed a test which included groups of three words. The person being tested is asked to find a fourth word, which has a connection to the first three. Following are some examples: Cheese, blood, music; board, magic, death; rock, time, steel; athlete, net, rabbit; mouse, sharp, blue.

We found that the Remote-Associates-Test was not appropriate for measuring *melioration*, principally because it wasn't suited for the target population we wanted to test—children in the sixth and seventh grades. Also, we felt that the linguistic level was too high for the young age we aimed to study. Reflecting these difficulties we engaged in developing a simpler test, which we called the Innovative Combinations' Test (ICT). In order to develop the tool and test it's validity we had to develop a training program and test its reliability to measure the skill. Following is a description of the training program and the validating process.

Age group

We have involved, in the process of validating the ICT tool, sixty school children that did not differ in demographic variants (Table 1). All were from a large urban area with a median socio-economic background. The participants were sixth and seventh grade pupils aged 11 and 12 years. This age group was chosen for several cognitive reasons. Problem-solving is a complex skill, defined as a higher order thinking skill. It develops in the Formal Operational Stage, according to Piaget's (1950) model of cognitive development. Thus, Vigotsky (1989) maintains, learning and development are mutual processes. Learning makes development possible, and in so doing, development advances learning. This Zone of Proximal Development, according to Vigotsky, includes the cognitive functions necessary for

the maturing process. With the help of learning, these budding phenomena turn into cognitive skills. The best kind of learning, therefore, is directed toward those incipient functions, moves on to development, and leads on from there.

Insert Table 1 about here

Sixth and seventh graders are in that zone of development which is closest to the Stage of Formal Operations. We hypothesized that participation in a training program, described in more detail below, would enable the participants to enter this developmental stage from a firm base.

Initially, we have tested the experiment and control groups in their abilities to solve ill-defined problems as well as their abilities to combine information, in order to verify that a common ground exist in these abilities before the intervention to take place (Table 2). We have conducted two tests: the Torrance (1974) sub-test “Unusual-uses” and the “Innovative Combinations' Test” (ICT).

Insert Table 2 about here

Training Program

According to Sternberg (1996), intelligence is not permanent, and can be changed and improved by interventions of various kinds. The training program which we developed for the purpose of validating our measuring tool was named Thinking-Different. This training program was developed with an online interface named WebQuest. It is a computerized tool which can be used for developing a learning environment of the sort which enables the student to browse Internet sites, and research a range of subjects through challenging tasks.

Dodge (2001) found that WeQquest encourages the development of higher-order-thinking skills in a problem solving environment. Dodge (2001) also delineated five guiding principles for constructing a high quality WeQquest environment abbreviated as F.O.C.U.S: **F**ind great sites, **O**rchestrate your learners and resources; **C**hallenge your learners to think, **U**se the medium, and **S**caffold high expectations.

The training program's goal was to engage the participants in creating combinations of a variety of pieces of information and generate new ideas in solving ill-defined problems. It challenged the participants to collect written, visual, and audio resources from the Internet. The resources could have been linked to form a web of connections. The participants collected materials and formed links according to specific tasks. For example, they were asked to surf virtual galleries displaying art works on a broad range of subjects quite removed, from each other. While looking at the different pictures, the students were asked to identify special elements and connect them in order to solve a problem that was introduced to them.

The interface's shell of the training program contained a component that was always available to the student if needed. In these sections the student could have found a thorough explanation about a variety of topics:

1. Introduction – The goals and expectations of the training program.
2. Task – A general list of the training program units.
3. Process – Directions on how to complete the various study tasks, and to the virtual teacher for assistance in the process.
4. Evaluation – Directions on how to evaluate the progress with some indicators.
5. Summary – A summary of the learning processes involved in this training program.
6. Problem reservoir – A collection of authentic ill-defined problems which can be selected and engage in their solution.

7. Teacher's guide – Presents theoretical information for the teacher in the fields of pedagogy and technology concerning WebQuest.
8. The Virtual Teacher – Presents the students with advice, as well as audio and visual reinforcement.

Five units were developed in the training program. The students could collaborate to solve the problems introduced in the unit or engage in self regulated learning as they see fit. Following is a brief description of each unit.

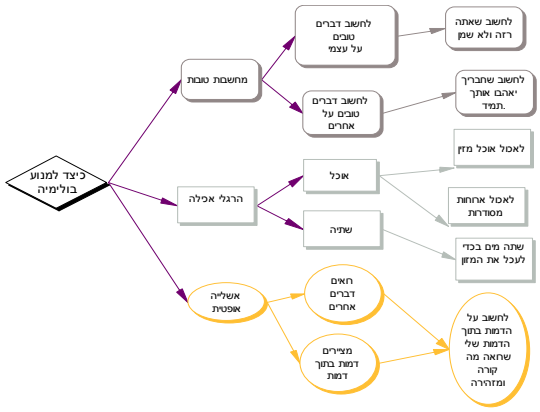
Unit #1 – Aimed at developing the technique of a random word. This technique challenged the student to find a random word that might help in generating a new combination of resources and solve with it the problem at hand. For example, when a student selected a problem whose solution required accessing a site named *Animator for Hire* he found virtual drawers from which he could draw random words presented as illustrations. He was then directed to choose a random word that might illuminate a new way to solve the problem.

Unit #2 – Aimed at developing the technique of escape, and teach a process of formulating strange, illogical sentences of escape. For example, when a student selected a problem, whose solution required accessing virtual galleries which display the artworks of the artists *Dali* and *Magritte*, he was asked to escape for a while from the problem and use the artwork as a spring-board for the problem's solution. Viewing a sequence of artwork from different artists aimed at teaching how strange combinations of resources could work as a stepping-stone to solve ill-defined problems.

Unit #3 – Aimed at developing the technique of combining materials, and teaching the student the process of locating random combinations of words through which he or she could come up with ideas to solve an ill-defined problem. For example, when a student selected a

problem, whose solution required accessing 'Brainstorming software online' (www.brainstorming.co.uk/onlinetools/websoftwarerandomwebsite.html)—a tool which presents random words, he was asked to combine random words whose significance could produce a relevant solution to the problem at hand.

Unit #4 – Aimed at developing the technique of considering a variety of ideas, and teach the student the process of dismantling and reorganizing the problem via concept-mapping. For example, in order to solve a problem, the students were asked to access sites such as optical illusions and music, and adopt ideas with a concept-mapping tool called *Inspiration*.



Unit #5 – Aimed at developing a subject matter course on water crisis, and teach the student the problems and solutions surrounding water conservation.

These five units were packaged into one CD titled "Thinking Different" that was distributed to the students who took part in the process of validating the tool for measuring the *Melioration* skill described herein. The units addressed a variety of learning styles that were exercised through experimental-learning involving multiple-intelligence.

The major limitation we have found in the course of this study with WebQuest was that teachers are deterred from using information technologies to teach high order skills. They tend to believe that these skills are better taught by great masters.

The Innovative Combinations Test

The Innovative Combinations' Test (ICT) aimed at examining the student's ability to meliorate ideas. We hypothesized that after taking the course "Thinking Different" the student would be able to better solve ill-defined problems. We therefore developed two versions of

the test, one version before the course and the second after the student took the course. The same tasks with minor nuances appeared in both versions.

The Innovative Combinations' tool was designed to measure the student's ability to solve real-life problems. Therefore, the starting point on each item of the test was a familiar daily life situation such as: A bus trip, a shopping situation in a supermarket, a telephone conversation, etc.

Real-life situations were situations to which technology has a great impact. For each situation a problem was introduced, where two random basic assumptions were presented. These basic assumptions stem from different fields of knowledge far removed from each other.

It was assumed that a person possessing the *melioration* skill would be able to search through the realm of human knowledge and create strange and far removed combinations of information-chunks that would suggest a viable way to solve a problem. In designing the measuring tool we created an artificial situation which brought the realm of human knowledge close to the student through two basic assumptions: a. In real-life we more or less rely on scraps of information for the creation of combinations which can help us solve our problems; b. in our daily-life we choose for ourselves the bits of information from which we create the combinations we need to solve our problems.

Ten life situations were chosen in both versions of the two tests, presented in Table 3.

Insert Table 3 about here

Scoring the items of the tool was also based on the behavioral objectives of the *melioration* skill (Passig, 2000, 2001, 2007). The skill is characterized by three main behaviors:

1. Consonance: Creating an innovative idea by making a personal cognitive connection between two areas which appear to be distant from each other.
2. Connotation: Creating an innovative idea by bringing upfront a personal association that attaches to a particular piece of information.
3. Courage to disregard: Creating an innovative idea by exercising courage to forget prior associations.

Every relevant idea which was drafted by a student was scored in a scale of 0-4 (see examples in Table 4).

- 0 – If no combination was created, or if the one created wasn't relevant to solve the problem
- 1 - If a combination of bits of information was created which reflects a personal connotation, but which has no correlation with the offered assumptions
- 2 - If a combination was created which reflects a correlation between the offered assumptions and a personal connotation
- 3 - If a combination was created which reflects the courage to forget, but which has no correlation with the offered assumptions
- 4 - If a combination was created which reflects a correlation between the offered assumptions, the personal connotation, and the courage to forget

Table 4 describes a sample of real-life situations with a pair of assumptions that were attached to them and some graded ideas based on the grading scale.

Insert Table 4 about here

The student's final grade in the Innovative Combinations' Test was the sum of points collected in all 10 items. This sum reflects the level of his ability to meliorate ideas (40 points would be considered 100%).

Validating the Innovative Combinations' Test (ICT)

In order to validate the test we built two parallel versions which served as the pre- and post-training ability to meliorate ideas. Both versions were shown to three experts—professors in leading universities specializing in cognitive studies, all three experts affirmed that the test indeed examines the ability to make combinations of disparate ideas, i.e., *melioration*.

The reliability of the test was examined via the parallel forms method. First, we sampled fifty-four 6th graders in a pilot study where they received two mixed versions of the test with a rotated order of the items.

In the pilot study, a *t* test was applied to the data and no statistically significant differences were found between the two versions (see Table 5).

Insert Table 5 about here

In addition to the *t* test, a *Pierson Correlation* was calculated for the total grade for version A and B. *Spearman Correlations* were calculated on each item in version A *vis-à-vis* version B (see Table 6). The analyses showed that there is a significant positive correlation between the total grade on version A and that on version B ($r\{52\}=.86$, $p<.001$). We also found that there was a significantly positive correlation between all the items in version A for their parallel items in version B, except for item #1, which had a correlation which was close to significant ($p = 0.58$). The results of the *Spearman Correlations* for each item are recorded in Table 6.

Insert Table 6 about here

In order to determine the internal consistency of each version, *Cronbach's α* was calculated for both versions of the test. We found a reliability of α=.81 and α= .77 for versions A and B, respectively (see Tables 7-8).

Insert Tables 7 and 8 about here

In this study, version A was administered before the training program and version B after the training program since no significant difference was found between the versions in our pilot study. The internal consistency test was administered to 60 other students. In version A we found that item # 5 was not consistent with the rest of the items. We therefore decided to remove it from the analysis of the results. After removing item # 5, a result of *Cronbach's α*=.81 was calculated. In version B we found a reliability of *Cronbach's α*=.79 (Tables 9-10).

Insert Tables 9 and 10 about here

Summary

The *melioration* skill that reflects the ability to solve ill-defined problems makes it possible to enlarge the student's toolkit for high-order thinking skills. This skill opens the opportunity to employ the language of innovation in learning processes. With it students would be able to cope successfully with complex real-life problems and generate solutions with resources at hand.

This study was conducted in order to validate the tool among middle-school students. However, we found that the teachers of this group age are having difficulties in teaching a skill with no conventional subject matter attached to it. This study, therefore, implies that in-service and pre-service professional training needs to educate teachers to be aware of the cognitive prospectus of their students and provide them with tools to evaluate not merely the knowledge they acquire but their cognitive status too.

The Innovative Combinations' Test (ICT) in this initial form aimed at providing the teacher with a tool with which one could examine progress in the students' ability to meliorate information. The importance of this measuring tool stems from the need to prepare students for tomorrow’s world. It will be a world which will demand flexible, innovative thinking based on the fragmented human drifting and chaotic info-sphere. We hope that this initial version of the ICT would open the path to curriculum planners and educators to better design learning experiences that would reflect the genuine needs of our alumni.

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Table 1. Demographic variants among participants.

		Experimental group	**Control group**	$\chi^2(1)$	P
		n	n		
Gender	M	16	16	0.0	p>.05
	F	14	14		
Grade	6^{th}	16	15	0.07	p>.05
	7^{th}	14	15		
Academic Mother	Y	16	11	1.68	p>.05
	N	14	19		
Academic Father	Y	14	12	0.27	p>.05
	N	16	18		

Table 2. Initial abilities to solve ill-defined problems and information combination.

	Experimental group n=30		**Control group** n=30		T(58)	P
	Average	SD	Average	SD		
Combining information	21.83	6.81	24.23	14.44	0.82	p>.05
Ill-defined problem solving	11.43	11.71	8.07	8.47	1.28	p>.05

Table 3. The Innovative Combinations Test – Two Versions

Companies throughout the world are working on improving appliances and services which help human beings in their daily lives.

Following are 10 familiar activities which we perform in our daily lives. How will we perform these activities in the future?

Next to each activity there are pairs of ideas from widely different areas. Your task is to combine the ideas and to come up with new ideas which will improve the activity.

	Life Situations and Ideas From Widely Separated Areas (version 1)		**Life Situations and Ideas From Widely Separated Areas (version 2)**
1	*Lunch at a restaurant* ❖ All the colors in the rainbow may be produced by combining the three basic colors; red, yellow, and blue ❖ A robot is a machine which can act according to orders	1	*Lunch at home* ❖ All the colors in the rainbow may be produced by combining the three basic colors; red, yellow, and blue ❖ A robot is a machine which can act according to orders
2	*Entering an elevator* ❖ Every item in a supermarket has a code. A computer reads the code and assigns the appropriate price ❖ Different people like different kinds of music	2	*Getting into a bathtub* ❖ Every item in a supermarket has a code. A computer reads the code and assigns the appropriate price ❖ Different people like different kinds of music
3	*A computer game* ❖ Conversation is a kind of communication ❖ My parents know when I don't feel well, or when I'm in a bad mood	3	*A TV game* ❖ Conversation is a kind of communication ❖ My parents know when I don't feel well, or when I'm in a bad mood
4	*A taxi ride* ❖ An Unman Air Vehicle (UAV) is a pilotless aircraft ❖ A computer can identify a person's voice	4	*A bus ride* ❖ An Unman Air Vehicle (UAV) is a pilotless aircraft ❖ A computer can identify a person's voice
5	*A mobile phone conversation* ❖ A suitcase folds up into a compact shape ❖ It's fun watching TV on a large screen	5	*A conversation on a conventional phone* ❖ A suitcase folds up into a compact shape ❖ It's fun watching TV on a large screen
6	*Shopping in a supermarket* ❖ When the refrigerator is empty, there's nothing to eat ❖ A cell phone brings people in different locations together	6	*Shopping on the internet* ❖ When the refrigerator is empty, there's nothing to eat ❖ A cell phone brings people in different locations together
7	*Sitting on a chair* ❖ Computers help people locate relevant information ❖ Medical specialists work in hospitals around the world	7	*Sitting in an armchair* ❖ Computers help people locate relevant information ❖ Medical specialists work in hospitals around the world
8	*Writing on a computer* ❖ Uri Geller reads others' thoughts ❖ Parents are able to distinguish between their children by listening to their voices	8	*Writing in a notebook* ❖ Uri Geller reads others' thoughts ❖ Parents are able to distinguish between their children by listening to their voices
9	*Watching TV* ❖ Every person's eye structure is different from every other person's ❖ Different people have different preferences	9	*Watching a movie* ❖ Every person's eye structure is different from every other person's ❖ Different people have different preferences
10	*Reading a newspaper* ❖ Electronic appliances are turned on by connecting them to electricity ❖ People fold notes and put them in their pockets	10	*Reading a book* ❖ Electronic appliances are turned on by connecting them to electricity ❖ People fold notes and put them in their pockets

Table 4. Examples of real-life situations, basic assumptions, and examples of students' combinations

Life situation	Basic Assumption	Grade	Combination of Information
Reading a Book or Newspaper	1. Electronic devices operate when connected to electric current 2. People fold notes and put them in their pockets	0	❖ When an electronic device is connected to electric current it works automatically
		1	❖ You can fold a newspaper, put it into your pocket, and read it anywhere
		2	❖ A folding book which can be put into your pocket and connected to an electric current
		3	❖ Connect a book to electric current, and once a minute it turns a page which can be put into my pocket. The pages are turned by my thoughts
		4	❖ You connect the book to the current, and it reads itself to you. When you've finished it folds up to the size of a piece of paper to save space
Watching a Movie or TV	1. People are distinguished one from the other by their eye structure 2. Different people have different preferences	0	❖ Everyone should respect everyone else
		1	❖ You can see movies at home
		2	❖ Everyone selects the film of his choice, which is screened on his glasses
		3	❖ There are theatres where the price is set according to the size of the screen. You go to the movies, enter a cubicle, and press your finger on the film you desire. ❖ A TV set with a memory feature that can remember which channel is your favorite
		4	❖ When you enter a certain room a camera photographs your eye, and according to the photo, shows which kind of movie you prefer ❖ The TV set has a laser which identifies a particular eye and shows the programs which that eye likes

Table 5. Comparison between two versions of the innovative combinations test in the pilot study (n=54)

Significance	t(53)	Standard Deviation	Average	Test Version	Item No.
0.30	1.04	1.54 1.63	3.22 2.94	A B	1
0.15	-1.45	1.52 1.67	2.24 2.59	A B	2
0.74	0.34	1.49 1.54	2.24 2.17	A B	3
1.00	0.00	1.57 1.47	2.98 2.98	A B	4
0.81	0.25	1.48 1.45	2.17 2.11	A B	5
0.74	0.33	1.42 1.45	2.60 2.19	A B	6
0.80	-0.25	1.51 1.41	2.28 2.33	A B	7
0.13	1.54	1.50 1.70	2.78 2.44	A B	8
0.81	0.25	1.75 1.73	2.46 2.41	A B	9
0.83	0.22	1.45 1.37	3.00 2.96	A B	10
0.45	0.76	9.24 8.89	25.63 25.13	A B	**Test total**

Table 6. Spearman correlations between the items in both versions of the Innovative Combinations Test in the pilot study (n=54)

Version B											
10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**Item #**	**Version A**
									.26	**1**	
								.38**		**2**	
							.45**			**3**	
						.51***				**4**	
					.31*					**5**	
				.35**						**6**	
			.42**							**7**	
		.44**								**8**	
	.56***									**9**	
.62***										**10**	

p<.05 *

p<.01 **

p<.001 ***

Table 7. Reliability of the Innovative combinations test in the pilot study – Version A

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A) Correlation Matrix

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**
A1	1.0000									
A2	.2760	1.0000								
A3	.3382	.2576	1.0000							
A4	.2281	.2631	.2112	1.0000						
A5	.3989	.2936	.2557	.1396	1.0000					
A6	.1809	.4271	.2914	.3072	.4391	1.0000				
A7	.1598	-.0627	.1876	.4155	.3513	.0804	1.0000			
A8	.1690	.1649	.3448	.2462	.3066	.3294	.1527	1.0000		
A9	.1719	.3777	.3913	.4021	.2038	.5916	.1364	.3570	1.0000	
A10	.3207	.2739	.4004	.4211	.4836	.4031	.5415	.4325	.3942	1.0000

N of Cases = 54.0

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
A1	22.4074	72.6611	.3974	.2658	.8019
A2	23.3889	72.6195	.4073	.3196	.8007
A3	23.3889	70.9969	.4864	.2924	.7920
A4	22.6481	70.3456	.4789	.3749	.7929
A5	23.4630	70.4797	.5159	.4614	.7889
A6	23.3704	70.0489	.5646	.5054	.7841
A7	23.3519	74.1946	.3449	.4737	.8072
A8	22.8519	71.7512	.4501	.2777	.7960
A9	23.1667	66.6698	.5519	.4757	.7843
A10	22.6296	67.0300	.6849	.5490	.7705

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A)
Reliability Coefficients 10 items

Alpha = .8090 Standardized item alpha = .8101

Table 8. Reliability of the Innovative Ccombinations test in the pilot study – Version B

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A) Correlation Matrix

	B1	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**B10**
B1	1.0000									
B2	.3946	1.0000								
B3	.4175	.4098	1.0000							
B4	.5182	.2814	.3094	1.0000						
B5	.1943	-.0512	.3638	.1159	1.0000					
B6	.1715	.4133	.2220	.2218	.0885	1.0000				
B7	.0164	.0347	.0087	.1751	.1473	.3455	1.0000			
B8	.2064	.1051	.3749	.5456	.2475	.1644	.3294	1.0000		
B9	.0549	.2483	.3067	.3062	.3799	.2615	.2285	.4561	1.0000	
B10	.2014	.2160	.2977	.4661	.1822	.2113	.1911	.3384	.3238	1.0000

N of Cases = 54.0

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
B1	22.1852	65.4745	.4128	.4506	.7589
B2	22.5370	65.6873	.3911	.4252	.7621
B3	22.9630	63.5458	.5342	.4334	.7427
B4	22.1481	63.2229	.5818	.5503	.7372
B5	23.0185	69.3015	.3157	.3258	.7701
B6	22.9444	67.3742	.3991	.2960	.7602
B7	22.7963	70.5426	.2727	.2484	.7747
B8	22.6852	61.8047	.5356	.4853	.7414
B9	22.7222	62.5063	.4934	.3948	.7477
B10	22.1667	66.6698	.4667	.2847	.7524

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A)
Reliability Coefficients 10 items

Alpha = .7741 Standardized item alpha = .7732

Table 9. Reliability of the Innovative Combinations' Test in the actual research – Version A

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A)

N of Cases = 60 N of Items = 9

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item Total Correlation	Alpha if Item Deleted
PREA1	18.2500	55.9873	.3995	.8060
PREA2	17.9833	54.2540	.4912	.7961
PREA3	18.0500	55.0653	.4357	.8022
PREA4	17.6667	51.8531	.4822	.7977
PREA6	18.4500	53.7432	.5158	.7934
PREA7	18.4833	52.4912	.5612	.7878
PREA8	17.9833	50.1184	.5509	.7884
PREA9	18.2000	48.7729	.6144	.7793
PREA10	17.7333	50.6056	.5311	.7912

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A)
Reliability Coefficients

Alpha = **.8125** N of Items = 9

Table 10. Reliability of the Innovative combinations test in the actual research–Version B

RELIABILITY ANALYSIS - SCALE (ALPHA)

N of Cases = 60 N of Items = 10

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item Total Correlation	Alpha if Item Deleted
POSTA1	20.8500	76.5364	.3599	.7833
POSTA2	20.7000	72.3831	.4820	.7697
POSTA3	21.8000	74.8068	.3866	.7808
POSTA4	20.8000	71.4169	.5421	.7628
POSTA5	21.8500	78.8415	.2663	.7928
POSTA6	22.0500	70.3195	.5605	.7601
POSTA7	21.9500	71.5398	.5032	.7670
POSTA8	21.3500	71.8246	.4158	.7786
POSTA9	21.5500	67.3364	.5713	.7572
POSTA10	21.1500	69.6551	.5090	.7660

RELIABILITY ANALYSIS - SCALE (ALPHA)

Reliability Coefficients

Alpha = **.7903** N of Items = 10