A taxonomy of ICT mediated future thinking skills

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Abstract: Our future society will be different from that we have known in the last fifty years. Futurists foresee that in the near decades the world's community will traverse through a period of rapid technological innovations that will change the foundations of society as we used to know. Changes will engulf all aspects of life (Gleick, 1999). These changes will have great impact on society, work, culture and art. People will have to innovate or evaporate. They will have to adapt continuously to never-ending permutations and engage in a never-ending adaptation. It makes sense, therefore, to assume that the graduates of today's schooling will need a different set of cognitive and learning skills reflecting the profound change that they will encounter. This paper traces the basic nature of future society and proposes a relevant taxonomy of future cognitive skills that will 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. This paper suggests an additional cognitive category to add to our teaching procedures named *melioration*, which we believe, is not addressed in today's curriculum.

Keywords: ICT, future, taxonomy, learning skills, cognition, knowledge

1. INTRODUCTION

From time immemorial, every generation's role was to prepare its next generation to the future. However, the nature of the future we are facing today does not resemble futures that past generations have been confronted with. The nature of the social, economical, industrial, and technological passages that our generation is facing will present our students with challenges that no past generation has encountered (Schwartz, 1999; Gleick,

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1999). This should bring us, at the turn of the century, towards examining the cognitive proficiencies that our children will need to succeed in their adulthood lives.

Dealing with such an issue in itself will probably raise substantial scepticism from various disciplines. How do you conduct such an examination? What are your research methodologies and do they insure the results indeed point to the skills that will be required from our graduates in the future?

It is unnecessary to point out that questions such as these are too convoluted to be treated in this framework. The methodological literature concerning future research methodologies is full with discussions of this nature (Kurian and Molitor, 1996).

We must emphasise that the research, which is partly reported here, does not suggest the results to be projections. We used *content analysis* as a methodology. We investigated how a variety of authors in various knowledge domains reckon, at present, what learning and cognitive skills will be required for our schools' graduates in future social, technological, industrial and economical environments.

For this purpose we have grounded our research on the tradition of cognitive taxonomies developed in the course of the recent half century. We have selected Bloom's taxonomy since it is a well-known taxonomy among educators world-wide. We have assumed to be able to modify it to reflect future thinking necessities of future adults.

Our research suggests that an additional cognitive proficiency should be reflected in today's curriculum. *Melioration* reflects a critical cognitive activity in future societies. In this paper we define this skill, and discuss its characteristics and importance.

Obviously the results of this research should be examined in light of the subjective perspective of the literature we have analysed to date. We do not aim to point out future cognitive skills. We do not have, in our present stage, the ability to estimate these skills accurately. All we can do is to estimate how we see future needs today. Thus, the goal of this study is to present these evaluations to those of us developing curricular materials.

2. THE KNOWLEDGE AGE

In the course of the 1990's, various cultures have already begun to experience a wave of changes characterised by a profound transition from the socio-economic state of trading information as a commodity into a global state of manufacturing knowledge (Perelman,1992; Kennedy, 1993). In this "knowledge-age" it is not sufficient to have skills of accessing information in order to achieve a relative advantage. The knowledge-age indicates that

there is a need of unique cognitive skills in order to achieve a successful implementation of information in real time. Those who will have the skills of collecting information in real time, as well as the ability to analyse, classify and organise it, will be those to achieve a social, cultural and economical advantage.

Most of the intellectual activity will be to amplify the value of available information. Thus, education in this age will have to be focused on knowledge: a successful implementation of information under the right circumstances and at the right time. The knowledge-age acknowledges the fact that shifts at the information overflow will be accelerated, and that the main role of people will be to add value to the exchange of information (Harkins, 1992; O'Dell, 1998).

In past generations the insulated elite was requested to manage information of large complexity and capacity in order to guide humanity in its efforts to improve life conditions. These efforts took place in relatively small communities. On the other hand, in a knowledge-age could be available information in great quantity to many people who will globally compete for its use. In order for societies to succeed in guiding their efforts to improve conditions effectively, they will need a significant amount of working teams that will be able to generate personal and/or collective, ethnic, and cultural added value (Passig, 1996).

2.1 The nature of future knowledge

Knowledge is the product of information processing. Thus, future knowledge will have local and personal characterisation. Knowledge as a product will reflect where and when it has been processed. To produce knowledge, societies will have to develop procedures that filter information and blend it with religious values, tradition, customs and even cultural or political preferences. Successful future societies will have to alternate their focal efforts from negotiating information into negotiating exclusive and local values, and retail them among different cultures.

3. THE RESEARCH PROCEDURE

In preparing this study we have used *Content Analysis* as our research methodology. After deciding upon the research technique we faced an unsolved dilemma. We had to define the depth and range of the literature we were about to cover in order to guarantee a reasonable validity of our results. Eventually we did not rule out this question, since we believe that such a research has to be extensive and continuous. Thus, we intend to conduct this

study in several stages. This paper summarises the results of the first stage of a continuous study in which we are engaged. In this first stage, we examined about 300 books from various future fields of interest as being categorised by the World Future Society (www.wfs.org). We selected from categories such as future technology, future economy, future life style, etc., a handful of representing recent publications (a complete list of publications can be found in Passig, 1998).

3.1 The theoretical framework

We assumed we would be able to find in the literature key words and phrases depicting future and most needed skills. In order to avoid formulation of lists concerning skills with no theoretical base, we had to choose a proper theoretical framework that will guide our efforts and consolidate our findings. Thus, we have examined various theories such as Bloom's taxonomy of cognitive skills (Bloom, 1956), Gardner's intelligences (Gardner, 1983, 1999), and Sterenberg's thinking styles (Sterenberg, 1997). We have decided that, in order to simplify the editing process of our findings, it would be better if we worked out from the most familiar theoretical framework: Bloom's cognitive taxonomy.

Many examined the nature of thinking in order to improve it and developed efficient learning strategies. During the years, different and various concepts were developed such as: high-thinking, productive thinking, interactive thinking, etc. However, Bloom and his colleagues were among the first to suggest a taxonomy of thinking constituents. Its essence was a layout of goals concerning fostering a type of thinking higher than remembering and understanding. Bloom suggested a hierarchy of six thinking levels/categories: *knowledge, comprehension, application, analysis, synthesis* and *evaluation.*

Over the years many researchers criticised Bloom's taxonomy (Nelson, 1981; Ennis, 1981; Seddon, 1978). Ennis for example claimed that the three highest levels in Bloom's taxonomy are thinking skills of a higher order. They supply a too thin guidance for training and they are not escorted with criteria for teaching evaluation. Many criticised the fact that there is an abundance of terms and definitions in the domains of psychology and education, and offered that instead of undertaking one term or another, it is better to adapt the use of the ultra-term "Higher Thinking Skills". This term is not exclusive to one type of thinking or another. It generally emphasises the contrast between lower order thinking skills (memorising, remembering, etc.) and thinking skills, which require more complex mental functions.

Nevertheless, since its publication (Bloom, 1956), the taxonomy has endured criticism and has developed in various directions. It was not feasible at the initial stage of this study to consider the variety of nuances that are

attached to Bloom's taxonomy. However, a more comprehensive discussion in a wider framework is needed in the future.

3.2 Bloom's taxonomy of cognitive skills

Bloom's taxonomy was meant to achieve two main objectives: curricular planning and achievement tests. His taxonomy offered the possibility to examine achievements in organised teaching procedures with regard to their behavioural goals. Table 1 shows a short version of Bloom's taxonomy and its behavioural objectives.

Table 1: Bloom's Taxonomy: definitions and behavioural objectives

Categories	**Definitions**	**Behavioural Objectives**
Knowledge	Any teaching purpose that needs just memorisation	Defines, outlines, identifies, titles, classifies, notes, chooses, attaches, memorises
Comprehension	A thinking process in which a message is changing form	Reverses. defends, discerns, assesses, explains, inclusion, expands, exemplifies, concludes, rewrites, summarises, translates, changes, supplements
Application	The ability to implement rules, principles, information, assumptions, theories, or other abstractions for new and real situations	Calculates, demonstrates, discovers, comprehends, improves, activates, predicts, understands, produces, relates to, divides into sections, develops, includes, attributes
Analysis	A thorough study to comprehend the structure of the learned content, its formal and logic way of organisation, in order to detect the elements, outlooks and methods the content is based upon	Divides into sections, graphically describes, classifies, distinguishes, identifies, concludes, emphasises, connects, categorises, confronts, compares
Synthesis	Establishing a whole new creation by combination of ideas from different sources, in a way that formats and moulds will be created, and will stand at the basis of the new creation	Combines and adds, creates, prepares, plans, improves, organises, rearranges, restructures, replicates, offers, tells, develops
Evaluation	Judging the values in the ideas through use of standards of estimations, determining the accuracy level, purposefulness and practicality of the details	Evaluates, compares, concludes, criticises, separates, attributes, summarises, supports, judges, claims, confronts, sets a norm

4. FUTURE THINKING SKILLS

Using content analysis we have researched the list of publications assembled from the World Future Society and examined key words and phrases depicting the possible nature of future thinking and learning skills. We then consolidated the large amount of findings into sub-categories along side with examples from the literature being researched (Passig, 1998).

Table 2 shows a condensed version of our findings organised under the same categories developed by Bloom and his colleagues. The suggested thinking and learning skills can be derived from the various challenges that human society faces in the short-term (5-10 years) and the median term futures (10-25 years).

Table 2. Future cognitive learning taxonomy

Categories	**Definitions**	**Behavioural Objectives**	**Key Words**
Knowledge	Achieving successful application of information in real time	To know where to find details; to master search strategies; to develop new symbols in a super-symbolic society; to develop conventions	To locate; to know where to search; to filter; to be updated; to leave out; to develop
Comprehen-sion	Multi-facet comprehension of a certain information; setting up fragments of information in various ways, when each composition has a different meaning	To expand existing models of thinking; to set the way of thinking in a wider framework; to invent symbols for concrete elements and to trade in these symbols; to create inferences and analogies in various ways	To expand; to set up in a wider framework; to invent symbols; to relatively connect
Application	Producing new ideas out of an old idea, in order to implement relevant information in real time and in different variations; creating new meaning for new symbols, new meaning for existing symbols and a new symbol for an existing meaning	To use codes and symbols: new and old; to change old codes and symbols	To initiate change; to be flexible; to decide; to reorganise
Analysis	Dividing a unit of information into its components and structuring varied and different relationships, even opposed	To create relations; to distinguish between relations; to analyse pieces of information in various ways; to evaluate	To make a relevant choice, subtle in a personal perspective; to

	to the unit's components; choosing from the ocean of dynamic information, out of personal/cultural/ ethnic judgmental values; setting fragments of information up in a multi-dimensional spatial structure; simulating various implications to various relations and simulating various perspectives in the multi-dimensional space	reliability of information and set fragments of information up in different relations putting in mind that the relations will be given to the influences of time space and personal intuition	disassemble and structure relations between fragments of information
Synthesis	Creating various combinations with different meanings out of given units of information.	To locate a separate element out of the pieces of information that it was taken from, in order to grant it a new meaning	To identify; to connect
Evaluation	Knowing how to choose suitable criteria and developing new criteria for an evaluation that will be useful for the continuation of learning process; evaluating the concealed as well	To evaluate qualitatively and quantitatively; to focus and to connect between the overall relevant items	to disqualify; to process; to check; to confront

Amazingly, or not, the driving forces behind these challenges are mostly information and communication technologies. The literature we have examined is a fascinating evidence that there exists today a consensus across the board that ICT is the pivotal force behind most permutations we are about to encounter on most realms of future reality. Moreover, the depth and pace of connectivity that ICT is about to deliver, is in our belief what will make ICT to the primary driving force for societal upheaval.

We suppose however, that ICT itself is the key that can help us deliver to our students the skills needed to successfully ride the transitions ahead. However, even if everyone does not agree with this statement, surely we need to prepare our next generation to undertake the kind of challenges that ICT will introduce to society, by providing our students with metacognitive tools for using ICT. Therefore we suggest that the suggested skills will be considered at least as such. It is evident from the literature we have examined that people who will master these skills will have great advantages over others.

Nonetheless, the suggested list of skills can be considered as a reminder that intelligence itself is evolutionary, and that we cannot rely solely on the way we defined cognitive skills half a century ago. This list of skills

however, cannot replace other lists or curricular objectives. It merely aims to enlarge existing definitions of thinking skills. It might be considered just as a proactive approach to the evolution of intelligence, since we really cannot predict where human cognition is heading.

5. MELIORATION

Summarising our findings we found that out of the literature stems a new category that could stand on its own. We struggled to choose a name that will support its independence, and chose the term "melioration." Finally, although the category could be a composition of several skills, it seemed that we should set it separately, mainly since it points to a type of cognitive skill with which we have not dealt in our curriculum so far. Especially since, according to the literature that we have examined, this skill is becoming increasingly important in future thinking procedures. See Table 3.

Table 3. Melioration: A future cognitive skill

Category	Definition	Behavioural Objectives	Key Words
Melioration	The skill to choose the suitable combination of information and implement it in problem solving in different situations, dependent on time and space, in order to meliorate the combination.	Consonance: to create an agreement; harmony; accord; personal new logical connection between two domains seemed distant from each other. Association: the mental notion of connection or relation between thoughts, feelings, ideas or sensations. A remembered or imagined feeling, emotion, idea or sensation linked to a person, object or idea	to adapt, to innovate simultaneously, to invent, to adjust

In order to meliorate information, one needs to embed in his/her thinking procedures ethnic, cultural, traditional and personal connotations. The following example can demonstrate what melioration is about: The president of one of the most successful high-tech companies in Israel, El-Rom, was once asked: Does El-Rom, in its way to success, imitates American technologies? What actually makes El-Rom unique and successful? He then answered:

"In many aspects, El-Rom adjusted American technologies and work procedures to the Israeli social and ethnic fabric. El-Rom has *adapted* manufacturing processes. That is, the company has innovated.

People from all over the world are coming to see and learn from that innovation. We also help them innovate in their own way."

At this point of time, we cannot predict with any certainty, what will be the hierarchy of skills that our graduates will be asked to master. However, it is certain that some of the skills we brought up to master are irrelevant to today's reality. Take for example memorisation. There are world-wide generations of students that attended schools in the 50s and 60s, who were forced to invest time and effort to master techniques for faster and efficient memorisation of poetry, mathematical tables and entire chapters of books. It was believed that by being able to recite prose by heart you would have some advantage in your adulthood life and in the work force. It was true then. It is not true anymore.

In this study, as opposed to the literature aimed at defining the core of intelligence, we searched for a different approach in defining the goals of education with regard to thinking skills. We embraced the proactive approach for a change and engaged to identify beforehand what might be the skills needed in the future of our students attending secondary education. These skills probably will become obsolete in the future. We need to be constantly proactive to identify the evolutionary nature of human intelligence.

6. CONCLUSIONS

Many people contend that ICT has not made a great difference in education, since it was introduced two decades ago into the classroom. Likewise, the body of literature reporting on the improvement of cognitive skills facilitated with computer assisted learning barely mounts to its expectations. The debate on this issue has taken ground in various scientific gatherings in recent years. However, it occurred to us the more we progressed with this study, that the reason for the poor results scientists are receiving worldwide from ICT performance in classes might be explained by another reason. It might be because we have been trying to teach a baby to crawl with skateboards. It might be that ICT could improve a different hierarchy of skills not listed in today's educational and cognitive goals. This study claims ICT is driving a much higher and sophisticated hierarchy of cognitive skills. ICT is challenging our broadly known hierarchy of skills. However, it is also providing us with ways to execute the potential embedded in it.

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