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Critical Thinking and Creative Thinking

- the self-assessment of

Algebra University College students

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Abstract - During the twentieth century, it became clear that national economies can make progress only by investing in human capital. Knowledge increases human productivity and creativity, and society can prosper only through human self-awareness, understanding of the world around them and by increasing the quality of their lives. In the information age, progress was made through information and technology, with particular emphasis on critical thinking. But in the conceptual economy of the 21st century, influenced by three key developments; over-supply, outsourcing, and automation, it has become clear that critical thinking, even with the help of high technology, is no longer sufficient to make a living or to be competitive in the labor market. In the 'Value age,' these capabilities need to be complemented by highly conceptual and highly sensitive traits. The integration of critical and creative thinking is a fundamental factor in personal productivity and the essential condition for achieving sustainable economic development. The self-assessment of Algebra University College students was designed to investigate the extent to which students integrated critical and creative thinking into their own circumstances and to explore whether there is a correlation between the type of thinking they are more inclined to and their study programs.

Keywords - critical thinking, creative thinking, conceptual age, value age, self-assessment

I. INTRODUCTION

The understanding of the 20th-century economy was based on the premise that future development depended on specific qualifications and experts, for example, lawyers because of their abilities to provide legal services, business administrators because of their abilities to provide financial services and computer programmers because of their abilities to provide software services.

But that understanding was brought into question under the influence of three forces; over-supply, outsourcing, and automation, as it was described by Daniel H. Pink in his book *A Whole New Mind* published in 2005. Throughout history, the lives of humans were defined by scarcity. The abundance of things has satisfied, or even over satisfied the material needs of hundreds of millions of people, and freed them from the struggle for survival in a broader context. The focus has moved from rational to sensibilities such as beauty, spirituality, and emotion. In business it no longer enough to create a product that has a reasonable price and

it is functional, now it also has to be beautiful, unique and meaningful. In the age of abundance, appealing only to rational, logical and functional needs is insufficient. Engineers still must figure out how to get things to work. But due to many other options, if things are not also pleasing to the eye or compelling to the soul, only a few will buy them. There is also the paradox of prosperity where even though people are liberated by prosperity, they are not fulfilled by it and more and more people are searching for meaning. At the same time, more and more labor is now done overseas, in Asia, North Africa, South America, and Eastern Europe at significantly lower costs than in the advanced world, as well as IT jobs; software and information technology industry. This is forcing knowledge workers to do what foreign workers cannot do, at a much lower price. Automation is the third force that is making a great impact on today's worldview. It is eliminating rote tasks because people cannot compete with the machines when it comes to logic and calculations. Technological progress is such that software can perform complex actions to the extent that it can perform preliminary medical diagnoses and some software can even write software. In the conceptual economy of the 21st century, it has become clear that people have to develop aptitudes that machines cannot replicate[1].

The capabilities that are arising from a logical and linear way of thinking, that was dominant in the Information Age need to be complemented by highly conceptual and highly sensitive traits in the Conceptual Age. In the 'Value Age', as is it also called, along with the intellectual capital, the greatest values are emotional capital, ideas, design skills, storytelling, and meaning. An increasing need for creative authors and artists shows that the integration of critical and creative thinking is a fundamental factor in personal productivity and today's sustainable economic development. Also, qualities such as intuition, creativity, and game-based approaches are becoming more and more important, as well as an extensive teamwork ability and an understanding of diverse cultures in the global context.

The research conducted through self-assessment of the Algebra University College students was intended to investigate the extent to which students integrated critical and creative thinking and have developed the most important and desirable skills required for the future.

II. TWO HEMISPHERES OF THE MIND

When Roger Wolcott Sperry, the Nobel Prize Laureate in Physiology or Medicine 1981 was still an undergraduate student and enrolled in the course Introduction to Psychology in the 1930s, taught by R. H. Stetson, on the first page of Sperry's notes taken in that class two questions were written that referred not only to the theme of the course but also to his own professional life: 'Where does behavior come from (nature or nurture)?' and 'What is the purpose of consciousness'[2]? Those were the questions he tried to answer throughout his scientific career while performing a series of medical and psychological experiments that have become famous.

Essentially, Sperry and his students showed that the left hemisphere controls the speech, and was considered dominant in all activities involving language, arithmetic, and analysis. The right hemisphere is mute and capable only of simple addition (up to about 20). However, it is superior to the left hemisphere in, among other things, spatial comprehension, such as understanding maps, or recognizing faces. Until Sperry's studies, it had been doubted whether the right hemisphere was even conscious. By devising ways of communicating between two hemispheres, he showed, to quote him: "indeed a conscious system in its own right, perceiving, thinking, remembering, reasoning, willing, and emoting, all at a characteristically human level, and ... both the left and the right hemisphere may be conscious simultaneously in different, even in mutually conflicting, mental experiences that run along in parallel." Discovery of this duality of consciousness opened new fields of researches, considerations, and discussions of a new generation of biologists, philosophers, and many others[3].

III. A WHOLE (NEW) MIND: INTEGRATION OF CRITICAL THINKING AND CREATIVE THINKING

Professor George Land with Beth Jarman in 1968 conducted a research study to test the creativity of 1,600 children ranging in ages from three-to-five years old who were enrolled in a Head Start program. This creativity test was also devised for NASA to help select innovative engineers and scientists and the assessment worked so well that he decided to try the test on children. It was a longitudinal study in which the same children were re-tested at 10 years of age, and again at 15 years of age. The astounding results showed that the proportion of people who scored at the "genius level", were[4]:

- 98% amongst 5-year-olds;
- 30% amongst 10-year-olds;
- 12% amongst 15-year-olds;
- 2% among 280,000 adults (average age of 31).

The primary reason for this, according to Land, is that there are two approaches to thinking processes regarding creativity:

- *Convergent thinking*: judging ideas, criticizing and/or refining them, combining and improving them, all of which happens in our conscious mind.

- *Divergent thinking*: imagining new ideas, original ones which are different from what has come before but which may be rough to start with, and which often happens subconsciously.

He highlighted that during education, children are taught to try and use both kinds of thinking at the same time, which is not possible. Instead of that, people should be allowed to split their thinking processes into various different states which would make each of them more effective[4].

Daniel H. Pink notes that there are usually two misconceptions about the human brain and mind which 'are opposite in spirit but similar in silliness'. The first considers the right brain a savior; and the adherents of this approach believe the right brain is the repository of all that is good, just and noble in the human condition. The second considers the right brain is a saboteur and although the adherents of this approach acknowledge the right hemisphere's legitimacy, they believe that using right-brain thinking creates a risk of sabotaging the economic and social progress made by applying the force of logic to human lives. But the reality is the right hemisphere will neither save us nor sabotage us and as is so often the case with reality, it is more nuanced.

After more than three decades of researches on the brain's hemispheres, the findings can be distilled into four key differences:

1. The left hemisphere controls the right side of the body; the right hemisphere controls the left side of the body.
2. The left hemisphere is sequential; the right hemisphere is simultaneous.
3. The left hemisphere specializes in the text; the right hemisphere specializes in context.
4. The left hemisphere analyzes the details; the right hemisphere synthesizes the big picture.

But instead of using lateralized brain functions as a metaphor for two different styles of thinking or attitudes to life, he suggests the terms L-directed and R-directed thinking he perceives to be operating in modern Western society and both are needed in order to craft fulfilling lives and build protective and just societies:

- *L-directed thinking* is sequential, literal, functional, textual, and analytic
- while
- *R-directed thinking* is metaphorical, simultaneous, aesthetic, contextual, and synthetic.

The thrill of reductionist, binary thinking is changing and dramatically reshaping our lives. L-directed aptitudes are still necessary, but they are no longer sufficient. Instead, the R-directed aptitudes such as artistry, empathy, taking the long view, pursuing the transcendent, increasingly determine who soars and who stumbles. It is a dizzying, but ultimately inspiring change[1].

In the Conceptual Age, the L-directed reasoning needs to be complemented by mastering six essential R-directed aptitudes. These six high-concept, high-touch senses combined together can help to develop the whole (new) mind this era demands.

1. It is not just a function that matters but also *DESIGN*. It is economically crucial and personally rewarding to create something that is beautiful, whimsical, or emotionally engaging.

2. It is not just an argument that matters but also *STORY*. The essence of persuasion, communication, and self-understanding has become the ability also to fashion a compelling narrative.

3. It is not just focused that matters but also *SYMPHONY*. Greatest demand today is not analysis but synthesis i.e. seeing the big picture and, crossing boundaries, being able to combine disparate pieces into an arresting new whole.

4. It is not just logic that matters but also *EMPATHY*. The ability to understand what makes their fellow woman and man tick, to forge relationships, and to care for others will distinguish those who thrive.

5. It is not just seriousness that matters but also *PLAY*. Too much sobriety can be bad for career and worse for general well-being. In the Conceptual Age, all people need to play.

6. It is not just an accumulation that matters but also *MEANING*. A world of material plenty has freed humans to pursue more significant desires: purpose, transcendence, and spiritual fulfillment[1].

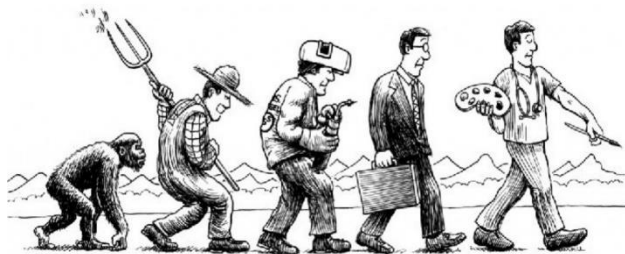


Image 1. Metamorphoses of human intelligence[5]

The movements in the global knowledge economy confirm findings of all researches mentioned, which place increasing demands on flexible intellectual skills and ability to analyze information, but in a way that integrates diverse sources of knowledge in solving problems so one can be able to deal with changes quickly and effectively. Increasingly more and more employers are looking not for employees with highly specialized academic skills, but those with 'good' thinking and communication skills. Employees who learn quickly and can solve problems, think creatively, gather and analyze information meaningfully are the most valuable and needed in the 21st century. Critical thinking is defined as thinking about one's thinking in a manner designed to organize and clarify, raise the efficiency of, and recognize errors and biases in one's own thinking. Critical thinking is not 'hard' thinking nor is it directed at solving problems[6].

Critical thinking is inward-directed with the intent of maximizing the rationality of the thinker, and one does not use critical thinking to solve problems—one uses critical thinking to improve one's process of thinking. It includes the ability to engage in reflective and independent thinking but it does not mean being argumentative or being critical of others. Although critical thinking skills can be used in

exposing fallacies and bad reasoning, they can also be used to support other viewpoints, and to cooperate with others in solving problems and acquiring knowledge. Clear and systematic thinking can improve the comprehension and expression of ideas, enhance language and presentation skills.

A breakthrough point, as stated Ljiljana Arar and Željko Rački[7], for more systematic creativity exploration was a famous lecture by Joy Paul Guilford, at Pennsylvania State College in 1950, entitled "Creativity"[8]. In this lecture, he emphasized how the measures of achievements (primarily school tests) are based on issues that point thinking to a one specific previously determined answer. As a counterpoint to that convergent thinking, the attention started to move to the, by then disregarded, the divergent thinking[7]. Guilford first proposed the concept of divergent thinking and later introduced its developed model as the main ingredient of creativity. Thus he associated divergent thinking with creativity, appointing it several characteristics: 1. *fluency* (the ability to produce great number of ideas or problem solutions); 2. *flexibility* (the ability to simultaneously propose a variety of approaches to a specific problem); 3. *originality* (the ability to produce new, original ideas); 4. *elaboration* (the ability to systematize and organize the details of an idea in a head and carry it out)[9]. The creative talent has central significance for industry, science, arts, and education [10] because, as he described, creativity is *sensitivity to problems; divergent thinking and ability to generate multiple ideas*[11], *creation of new patterns, a transformation of knowledge and meaning or use the functions of objects in a new way*[12].

The suggestion that critical thinking is incompatible with creativity is a misconception, as creativity is not just a matter of coming up with new ideas. A creative person generates new ideas that are useful and relevant to the task at hand. Critical thinking plays a crucial role in evaluating the usefulness of new ideas, selecting the best ones and modifying them if necessary. It is important to become aware of the connection between critical thinking and creative thinking skills. Future economic growth and social progress in the information age rely on innovation. In addition to technical know-what and know-how, the core skills for innovation are critical thinking, creativity, problem-solving, global collaboration and communication[13]. The top ten skills in the 21st-century workplace that are considered essential according to the World Economic Forum[14] are as listed in Table 1.

2015	2020
1. Complex problem solving	1. Complex problem solving
2. Collaboration with others	2. Critical thinking
3. People management	3. Creativity
4. Critical thinking	4. People management
5. Negotiation	5. Coordinating with others
6. Quality control	6. Emotional intelligence
7. Service orientation	7. Judgement and decision making
8. Judgement and decision making	8. Service orientation
9. Active listening	9. Negotiation
10. Creativity	10. Cognitive flexibility

Table 1. Top ten essential skills in the 21st-century workplace according to the World Economic Forum.

The Lee Watanabe-Crockett created a similar list of the ideal set of skills to strive for i.e. the most important characteristics and universal traits and integrated values that the effective critical thinkers (should) possess [15]:

- *Curiosity* - about a wide range of topics and generally have broad interests. They tend to have a healthy inquisitiveness about the world and about people. An understanding of and appreciation for the diversity of cultures, beliefs, and views that encompass humanity are one of the hallmarks of a great critical thinker. This also makes them lifelong learners.
- *Compassion* – embracing the emotional and instinctual as much as the intellectual. They act as much with their hearts as they do with their minds. There is already enough judgment and segregation in the world, much of it stemming from lack of a clear understanding of one another's secret history of perseverance through often unimaginable suffering.
- *Awareness* – of the fact there are opportunities in which to apply critical thinking skills all around us as well as always being alert about the chances to apply their best thinking habits to any situation. A desire to think critically about even the simplest of issues and tasks indicates a desire for constructive outcomes.
They never stop asking questions and enjoy exploring all sides of an issue and the deeper facts hiding within all modes of data. As such, those who think critically also tend to be instinctual problem solvers.
- *Decisiveness* - many situations that call for critical thinking also call for quick and decisive action. When they think critically, it is important to weigh options and imagine the outcomes at the moment with speed and clarity and being able to put aside fear when it comes to making decisions. In essence, critical thinkers like to move things forward rather than moving backward or procrastinating, because they thrive on progression. In addition to this, choices often have to be made even when we do not have all the information we need to make them with confidence. When facing any kind of a challenge, someone often has to take the lead and make the hard decisions others shy away from. Effective critical thinkers realize that, more often than not, it is necessary to take the initiative and make a decision even if it ends up being the wrong one. To them, that is preferable to not making any decision at all.
- *Honesty* - is important in any sense, but it is especially important in regard to critical thinking. Moral integrity, ethical consideration and action, and global citizenship practices are all hallmarks of effective critical thinkers. It is not a surprise that honesty resides at the core of all these things. We see in such people a strong desire for harmony

and fulfillment in the world, and the part of attaining this involves pursuing honesty in all endeavors and relationships.

- *Willingness and flexibility* - encompass a number of key considerations for the critical thinker. They include but are not limited to things like the ability to: learn from their own personal mistakes and shortcomings, challenge the status-quo when the need arises, open-mindedly embrace other opinions and views that challenge their own, reconsider and revise their opinions in the wake of new evidence, listen actively rather than simply wait for their turn to talk and constantly improve, learn, and excel.
- *Creativity* - there's no question that effective critical thinkers are also largely creative thinkers. Creativity has unquestionably defined itself as a requisite skill for having in the collaborative modern workforce. Critical thinking in business, marketing, and professional alliances relies heavily on one's ability to be creative.

IV. THE RESEARCH METHODOLOGY

A. Research Goals and Methods

The aim of research conducted during January 2019 among the Algebra University College students of computing (technical field), digital marketing (social sciences field), and design (artistic field), was to determine if students integrated the traits of critical and creative thinking into their own thinking process.

The questionnaire was anonymous and it consisted of 12 questions with the possibility of choosing between 3 answers, as well as 12 claims with which the students were asked to express their attitude according to the 5 degrees of the Likert's scale of agreement.

The questions were categorized according to the 6 traits stated by D. H. Pink. The results of the survey themselves are analyzed according to them. Through these survey questions and claims, the research addressed the extent to which the students are ready to integrate critical and creative thinking traits, while determining which type of thinking the students were more prone to based on their particular study program and gender.

A quantitative method was used for the research results analysis, and the data processing of the survey results was made by the Microsoft Excel tool.

B. Participants

113 students were polled in the survey. The overall ratio of all participants according to gender is 73% male to 27% female participants. 7% of surveyed student are graduate students and 93% are undergraduate students. The highest percentage of student population sample included study computing (Applied Computing and Multimedia Computing), followed by social sciences (Digital Marketing) and the lowest percentage study design (Visual Communication Design and Creative Design and Communication Management). The participant structure according to their study program is visible from Chart 1.

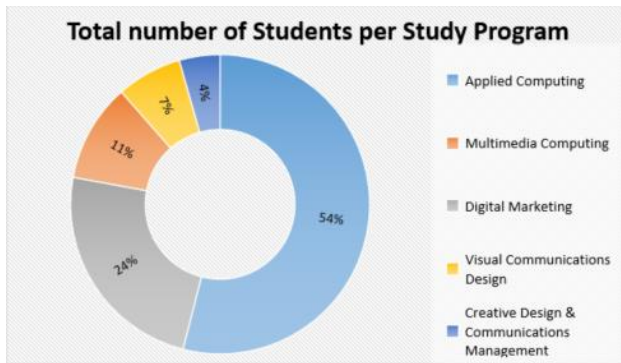


Chart 1. The participants' structure per study program

C. Research Results

The data of the poll itself were interpreted through the 6 categories named by D. H. Pink. Furthermore, three dimensions the first of which is the participants' study program, are taken into account. Apart from the names of the study programs, the first dimension further entails the field of studies, i.e. technology, social sciences, and arts. The second dimension is possible the gender differences and the third dimension is possible differences in students' opinions that arise from the distinction of their private and professional life.

Interpretation of results by categories:

1. Functionality vs. Design

By the first category questions, the intent was to determine whether students consider that the functionality of an object is more relevant or the design of an object is more relevant, or they perceive them as equally important. The same question was asked specifically for private and specifically for the business environment. The survey results showed that 49% of technology students deem functionality relevant, while only 29% of art students share their opinion. Contrary to that, only 2% of technology students think the design is relevant, with 15% of art students feeling the same way. The largest percentage of students of all study programs, around 60%, believes functionality and design are equally important. The results also showed there is no significant difference in opinion in regard to the participants' personal and professional life.

2. Arguments vs. Story

The second category question was aimed at mastering new knowledge, i.e. whether in these situations the arguments or the story told and the added context was more relevant. The survey results showed that the students of all study programs find arguments and the story told equally relevant. This was confirmed by 68% of technology students, 70% of social sciences students and 77% of art students. In addition, no significant difference was found in regard to their private and professional life.

3. Details vs. Big picture

In the third category, students were asked whether it was more relevant for them to focus on details or the big picture. It is visible from the Chart 2. that the students of all areas find it equally relevant to focus on details and the big picture.

Focus vs. Big picture

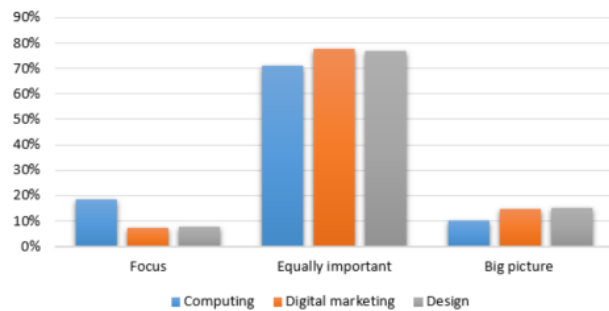


Chart 2. Distribution of the answers to the question about the importance of *Focus* in regards to *Big picture*

4. Facts vs. Empathy

The fourth category refers to facts and empathy. The Chart 3. shows that to students facts are more relevant in a professional environment (cca 60% find facts more relevant), while in personal live facts and empathy are equally important (according to 80% of the participants). No significant difference in students' opinions is observed in regard to the area of their studies.

Fact vs. Empathy

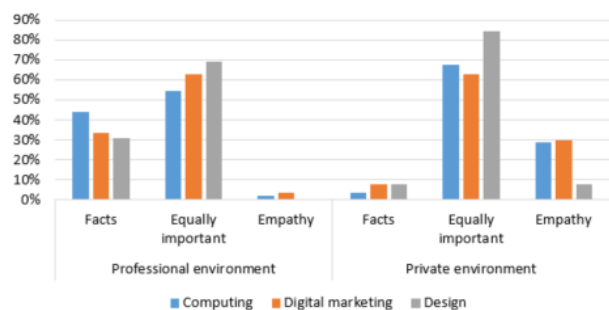


Chart 3. Distribution of the answers to the question about the importance of *Fact* in regards to *Empathy*, both in a professional environment and in a private environment.

5. Seriousness vs. Play

In the fifth category, the students were asked about the importance of play in regards to seriousness in a professional and a private environment. The results showed students think that in a professional environment seriousness is more important (cca 60% of them) than play, while in personal life the majority considers play and seriousness are equally important (cca 70%). No significant differences in opinions were observed in regard to the participants' study programs.

6. Accumulation vs. Meaning

In the sixth category, the students were asked whether material (accumulation) or spiritual wellbeing (meaning) is more relevant. The results have shown that for the majority of students material and spiritual wellbeing are equally important, both in their professional and their personal life. Students percentage agreed that the material and spiritual wellbeing are equally important, both in a professional and personal environment, is listed in Table 2.

Study program	Professional environment	Private environment
Computing	69%	59%
Digital Marketing	70%	78%
Design	69%	54%

Table 2. Percentage of the students that agreed with the statement: *The material and spiritual wellbeing are equally important*, both in a professional and personal environment.

Based on gender, three notable differences were observed:

1. when solving a problem, more male students prefer working step by step, one section at the time (75%) than female students (60%);
2. more male students (66%) than female students (50%) prefer to act based on their own ideas and to come up with their own solutions than to follow specific predetermined rules and structures;
3. more male students (36%) than female students (20%) do not like unpredictable things.

D. Limitations and recommendations for future researches

It is important to emphasize the difficulties encountered during the research and ultimately its limiting elements; the method of distributing the survey was limited to sampling, and a smaller number of design students is generally enrolled in the art study programs compared to computing students at this time on Algebra University College. In future research, it would be advisable to conduct research on an equal sample of students of each study field so that more relevant data can be acquired.

V. CONCLUSION

The majority of all surveyed students consider that function and design matter equally, it can be noticed that design students nevertheless give a much greater advantage to design than functionality.

Also, the majority of all surveyed students find arguments equally relevant as the story, both in their private and professional life, as well as the majority of participants, focus on the details consider equally important as the big picture. But, according to their opinion, the arguments are more relevant in a professional environment, while in personal live arguments and empathy are equally important. Also, they think that in a professional environment seriousness is more important than play, while in personal life the majority considers play and seriousness are equally important. It can be concluded that empathy and play are not yet included in the professional environment to the extent that it would be instructive, and that rational thinking overcomes creativeness.

However, for the majority of students accumulation and meaning are equally important, both in their professional and their personal life.

It is evident that in an ever-changing human existence and world, the one thing remains the same: by adopting the new ways of thinking and behaving, such as in this time integrating the critical and creative thinking, people can again piece together the longtime split mind into a whole (new) mind and thus adapt to new environment by creating a whole (new) world.

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