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CONSTRUCTING E-LEARNING TOOLS FROM HEURISTIC METHODS: MULTIPLE WHYS, CIRCLE OF ANALOGIES AND STEPWISE CONVERGENCE

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Abstract: *I discuss various methods which may benefit from online implementation, supporting e-learning in the area of creativity and effective thinking at all educational levels, from kindergarten to graduate programs. All procedures comprise a virtual laboratory, capable of generating actual creative solutions to real problems. Tools for creative thinking may be implemented as online procedures allowing the user to conduct heuristic group sessions. I provide examples of individual-user heuristic methods (multiple Why? questions, circle of analogies) and a group-based method (discussion 66 which involves stepwise convergence of ideas generated by semi-independent subgroups).*

Keywords: creativity, e-learning, heuristics, innovation.

INTRODUCTION

Specialized e-learning tools for managing creativity allow us to combine critical and rational thinking which relies on clarity and explicitly defined criteria, with heuristic methods. Some of such methods are epitome of creative disorder, but others may be based on orderly, almost algorithmic approaches (e.g. Duran-Novoa et al., 2011). I believe that both types of methods, if applied with rigor ("disciplined imagination", Cornelissen 2006), may be implemented in various e-learning tools and perform functions which enable creativity (see also Barak 2013; Chang 2011). In this paper I describe both the logic and mechanics of selected heuristic methods and ask which of their features are amenable for implementation in an online environment (Jasieński 2012a).

1. MULTIPLE "WHY?" QUESTIONS – TRAJECTORIES OF ANSWERS FOR E-LEARNING

The same question "Why?" is asked repeatedly because at each stage the answer it yields is different. This strategy allows us to probe deeply into the causes of problems and, what is equally important, branching points in this path are created when several answers are provided to a given "Why?"; with a single answer, a straight path is simply elongated. A branching system thus arises and it explores a multitude of viewpoints and aspects of the problem. Some of the paths explore purely theoretical or abstract aspects (such as: ethical, philosophical, aesthetic) and other paths may lead to practical issues, connected with technological, managerial or financial details.

1.1 An example

The price of our product is too high, compared to the products of our competitors. Why? [I provide three possible answers, each followed by a sequence of several possible trajectories of answering.]

Answer A (one of many possible): Because the production process is very costly. Why?

> Answer A-1: Because costs of electricity are very high during one of the stages of the production process. Why?
>
> > Answer A-1-1: Because that stage occurs during the time when electricity is more expensive. Why?
> >
> > > Answer A-1-1-1: Because the production process begins always at the same time, in the morning. Why?
> > >
> > > > Answer A-1-1-1-1: Because the necessary substrate arrive always during the night. Why?
> > > >
> > > > > Answer A-1-1-1-1-1: Because the traffic is much lower during night hours. Why? STOP

Answer B (one of many possible): Because the material used in its production is very expensive. Why?

> Answer B-1: Because we use as one of the components, to improve resistance to scratching of the surface of our device, a chemical compound which is very expensive. Why?
>
> > Answer B-1-1: Because there are no known chemical compounds with similar properties. Why?
> >
> > Answer B-1-2: Because this compound is mined in only one location in Siberia and imported, which makes it expensive. Why?
> >
> > > Answer B-1-2-1: Because trade tariffs for imports of this component are very high. Why?

Answer B-1-2-1-1: Because the Congress wants to protect the local companies which produce alternative compounds. Why? STOP

Answer B-1-2-1-2: Because raising trade tariffs is part of a political conflict between two countries. Why? STOP

Answer B-1-2-2: Because there are no cheaper methods of obtaining this compound which is know to occur in basalt rocks in Alaska. Why?

Answer B-1-2-2-1: Because a new research grant proposal aimed at developing such methods was rejected by a granting agency. Why?

Answer B-1-2-2-1-1: Because the best scientist left the research team. Why?

Answer B-1-2-2-1-1-1: Because she entered a convent. Why? STOP

Answer B-1-2-2-2: Because the previous research project showed that all known methods of technological processing of basalt rocks are not effective in this case. Why?

Answer C (one of many possible): Because the packaging of this product is hand-made and old-fashioned. Why?

Answer C-1: Because the marketing campaign for this product was targeting mostly older clients.Why?

Answer C-1-1: Because it has been decided that our firm should be directing its attention towards such clients. Why?

Answer C-1-1-1: Because we have assessed that the economic potential of older clients will grow in the near future. Why?

Answer C-1-1-1-1: Because of the demographic trends, i.e. the society is getting older. Why? STOP

1.2 Benefits of an e-learning implementation

Software facilitates keeping track of the growing tree of answers, which quickly becomes unwieldy with many branching idea threads. The system should be able to provide output in the form of a listing of answers. However, the example shown above illustrates how difficult to use and confusing a simple listing of proposed ideas can be. Clearly, a more intuitive visualization of the results is essential for an e-learning system to provide any advantages. Figure 1 shows the simplest approach at bringing order to the generated tree of responses. Each of the boxes in the flowchart should be clickable, with an option of becoming a new branching point from which a new branch (idea thread) begins.

Each end-point is marked with a „Stop“ indicator proposed by a participant and accepted by the majority of others. Subject to assessment are only end-points of each trajectory of questions. Such social component, when the participants decide about

the pattern of branching and generation of ideas, and also when software allows for accumulation of feedback for each idea thread, is worth implementing. Also, the icons with answers may have size proportional to the positive interest they generate among the users (for example, the more votes, the larger the size). This element ensures that the feedback received from the community of users is dynamically built into the visual representation of the proposed solutions.

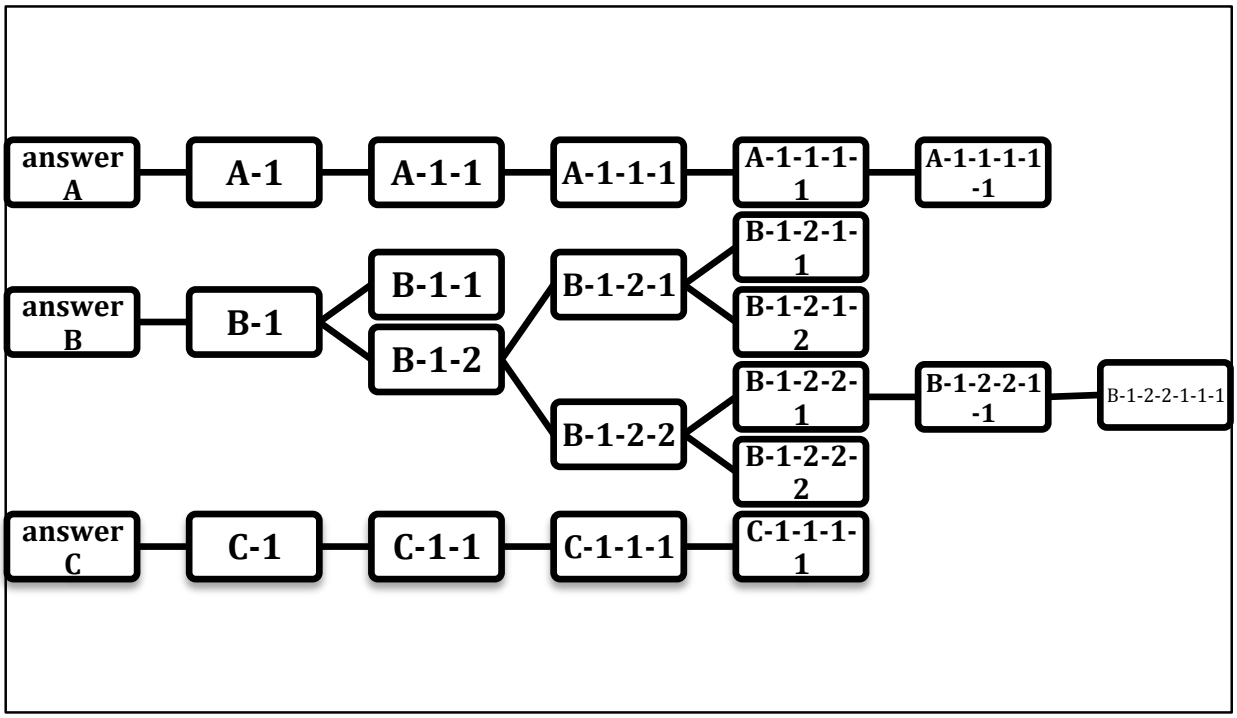

Figure 1. A flow-chart-like structure of branching of responses to questions „Why?“ from the example above

Source: Own elaboration

Finally, one could propose quantitative indexes measuring the rate with which alternative answers are generated for each "Why?" question, thus enabling the use of such e-learning tool for educational and psychological research (see e.g. Butler & Kline 1998; Vessey & Mumford 2012).

2. MANAGING METAPHORICAL THINKING

Deep exploration of various aspects of the focal issue may be achieved through methods based on a controlled and rigorous use of imaginative analogies (Cook & Gordon 2004; Hey et al., 2008). This sounds almost like a paradoxical statement: analogies and metaphorical thinking are usually not compatible with disciplined and methodical analysis (Indurkhya 2007). However, analogy-based methods, nicely summarized and developed for the Polish readers by Nęcka (1994), illustrate that one can combine both ways of thinking. I consider below how they could be implemented in an IT-based environment.

As Oswick et al. (2002) point out, metaphors (which are forms of analogies) may serve either as tools which strengthen our similarity-based "cognitive comfort zone" or, through the use of dissimilarity-based approaches (anomaly, paradox, and irony) may help in building the "cognitive discomfort zone". They argue that is where the truly creative solutions lie. One may also capture the difference between these alternative ways of dealing with analogies by describing two strategies.

First may be described by the phrases "make strange into familiar" or „tame the unknown" (Gordon 1961, Nęcka 1998, 2001). It makes it easier to understand or explain complicated concepts or things by comparing them to concepts or things that are either well understood (e.g. steam engine), familiar (even if not understood, e.g. love, weather, stock market behavior or internet) or just simpler (e.g. comparisons of light vs dark, light vs heavy, light vs fatty). When one compares an optimization procedure to a trip in a mountainous area and searching for the tallest peak, this analogy captures very effectively the essence of optimization. We have made a difficult concept, the one that can be truly understood after several years of studying statistics and quantitative methods, into something the sense of which can be intuitively grasped, by comparing it to a familiar activity (a trip to the mountains). Similarly, the advanced problem of sound digitalization, i.e. a conversion of a sound wave into millions of discrete fragments, each lasting 1/44,000th of a second, can be compared to chopping dill.

Second strategy is to "make familiar into strange" – it makes it possible to see new and exciting aspects in things that are well-known or plain (Gordon 1961, Nęcka 1998, 2001). We are trying to inject mystery or excitement into objects, people, or issues that are so familiar or taken for granted that we are no longer interested in them. We hope to rediscover in those familiar topics streaks or echoes of fundamental and important processes, that were there forever, and that allow us to re-connect with long-forgotten values. In the process of such rediscovery, we may create new ideas that maybe will lead us to form new ways of seeing the world and, in Steve Jobs's words, „put a dent in the universe". When I say that my Macintosh laptop is like a crusader's sword with which to fight infidels (however silly or objectionable this analogy is), I try to show that my good old laptop is more than a piece of hardware, but that I try to do important educational things with it. An unexpected analogy may capture the nature of the problem more effectively than long explanations.

What is referred to as a "focal issue" could be of very diverse nature (see also Cornelissen 2004, 2005): it may be a product which is considered for commercial introduction, a person (e.g. a politician whose election campaign is being planned, a band considering a change of their image), an organizational or social problem to be solved (e.g. alcoholism, low morale of the employees, poor involvement of citizens in the life of a local community), or a controversial social issue (e.g. abortion, in vitro).

3. CIRCLE OF ANALOGIES

This qualitative method, originally proposed and named „circept" by Kaufmann et al. (1975), relies on combining our ability to generate analogies with a sense of graphical order, i.e. ordering analogies in a visually meaningful diagram.

3.1 The procedure

1. finding a large number of analogies of the focal concept, with being able to explain and justify each particular analogy – this step should not be just an exercise in random creativity;

2. forming pairs of analogies which represent the ends of a conceptual axis – they should be linked in a justifiable way, but may emphasize mutually exclusive or opposite ends of a spectrum of characteristics;

3. naming the most important axes with names that are meant to reflect some deep or underlying quality, that had not been obvious to us before;

4. arranging the named axes in the form of spikes of the wheel in such a way that the order of axes can be justified, i.e. two axes that are closer to each other in some dimension of characteristics (i.e. have higher relatedness) should be also closer on the circept graph.

5. adding visual representation of a quantitative criterion called by Nęcka (1994) „relative accuracy" to strengthen the qualitative nature of the analysis. Two analogies which form two ends of one axis do not necessarily have to be equally accurate in capturing the spirit of the focal concept. The quality (aptness, inventiveness, attractiveness, freshness etc.) of each of the analogies used in the circept is therefore assessed using some quantitative scale. As a result, the circept diagram becomes a hybrid with a radar (spider) chart, and e.g. Microsoft Excel produces radar charts that can be adopted to the circept method, with an even number of the spokes of the wheel. Such analysis, combining qualitative and quantitative elements, is much more robust and, potentially, useful.

3.2 An example

The focal issue for analysis is „a grant from the European Union", as seen through the eyes of a scientist from a university or a research institute. For offices for technology transfer or for international scientific exchange to be effective in their work among scientists, it is essential that they understand all possible implications that obtaining a grant has for recipients. Such implications are not exclusively positive. Office managers must appreciate the diversity of responses to a grant that appear in the community of scientists. Only then can they design effective strategies of encouraging, overcoming scepticism and managing grant-related behaviors among the potential grant applicants.

Figure 2 shows the generated analogies, suggests how they could be paired, to create six axes, and proposes one way of arranging the axes on the diagram. The axes can

then be named, in an attempt at generalizing insights. The „maternal care – gullibility of EU" axis may reflect the underlying problem of „welfare addiction"; the „gates to heaven – gates of hell" axis represents the underlying problem with „bureaucracy"; the „ostracism-prestige" axis emphasizes the importance of „envy" as a factor.

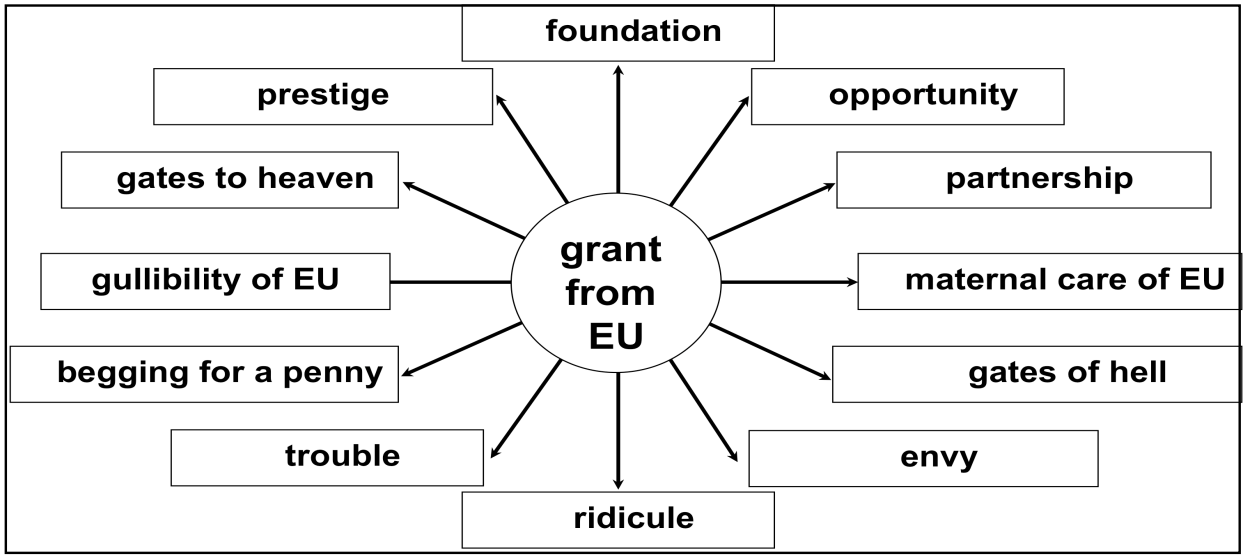

Figure 2. A traditional circept diagram, with pairs of analogies forming axes, each with a particular interpretation

Source: Own elaboration

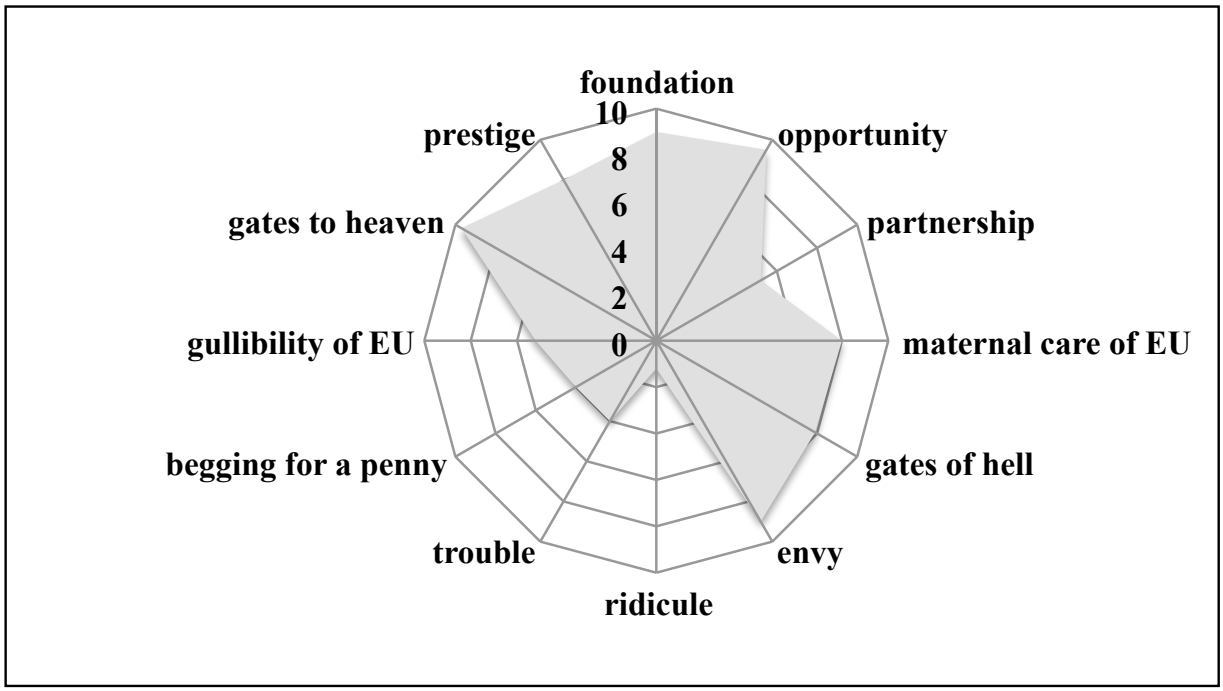

Figure 3. A hybrid circept-radar diagram: combining circept diagram with quantitative data.

Source: Own elaboration

The participants may think that, for example, the benefits from obtaining the European grant („gates to heaven", Fig. 3) are greater (average index of quality of, say, 9.7) than the substantial troubles associated with administering the EU-related paperwork („gates of hell", index of 7.9). Consequently, this particular axis is weighted towards benefits rather than troubles, and this may affect the conclusions derived from the circept.

3.3 Benefits of an e-learning implementation

Drawing an active (rather than purely graphical) circept diagram can be very effectively facilitated by appropriated procedures: pairs of analogies can be assigned colors, linked by axes, and added to the diagram. Positions of the axes on the diagram should be adjustable by dragging, since this step is conceptually difficult and requires many "what if" adjustments. A specialized tool for quantitative assessment of the aptness of analogies should be easily activated to allow transformation of the traditional circept diagram into the radar diagram option.

4. STEPWISE CONVERGENCE OF IDEAS GENERATED BY SEMI-INDEPENDENT SUBGROUPS

During a group debate there often occurs a phenomenon of implicit agreement between the participants that one of the ideas proposed during the debate is better than others. It is usually caused by somebody's spontaneous remark, issued without much analysis. This phenomenon negatively impacts the creative potential of the entire group, since the participants unconsciously direct their creative insights into the direction suggested by that remark. Other directions of thought wither away, which results in a loss of diversity of ideas (Greenberg & Baron 2000).

One of the remedies, known as „Discussion 66" (see Denton 1999; Proctor 2002), involves splitting the group into small subgroups which then generate ideas separately and then confront them with the outputs of other subgroups. Consequently, idea generation occurs in the subgroups along independent trajectories and, therefore, the danger of becoming fixed on one particular line of thought is minimized. One could see similarity of this approach to the Delphi method (Linstone & Turoff 2002), which could be called „stepwise convergence of ideas of independent experts".

4.1 The procedure

Figure 4 shows the stages forming this method which begins with receiving the description of the problem to be solved; subgroups work under time constraint (in 6-minute sessions, to motivate participants), and then present their ideas in front of the entire group. After such open discussion, subgroups return for the next session. Adopting and developing other subgroups' ideas is allowed and encouraged.

The process is repeated until there is convergence of the proposed solutions, i.e. ideas proposed by all subgroups are basically the same, with the assumption that the

process of convergent development has resulted in an optimum (i.e. the best in a given situation) solution. Table 1 shows one scenario of such convergence, during which all three subgroups at stage 4 adopt and modify subgroup's B solution developed at stage 3, but during the final debate the modification C4 developed by subgroup C is accepted as the optimum solution (see also Fig. 5). Please note that the final outcome of this process, denoted as C4(B3(A2(B1))), is a composite of creative contributions of all three subgroups, adopted and modified at different stages of the process!

4.2 Benefits of an e-learning implementation

The dynamics of subgroups switching between the ideas which have been proposed in an earlier round by other subgroups, or continuing with development of its own ideas, becomes quite complex (as seen in Fig. 5). Therefore, an online system helps in management of ideas, both within and among subgroups. Importantly, the entire process may be carried out only online, with subgroups maintaining their composition and having exclusive access to their virtual "workbenches" (subgroup profiles). While access to each workbench is limited to members of the appropriate subgroup, all participants have access to the general forum, to exchange ideas between the successive rounds. Each subgroup may choose to apply, at any stage of the process, more explicit and quantitative multi-criterial evaluation of ideas rather than intuitive assessment. Duration of particular stages (e.g. of idea generation and idea evaluation) and number of rounds may be set by the moderator, with added functionality of participant notification of approaching deadlines.

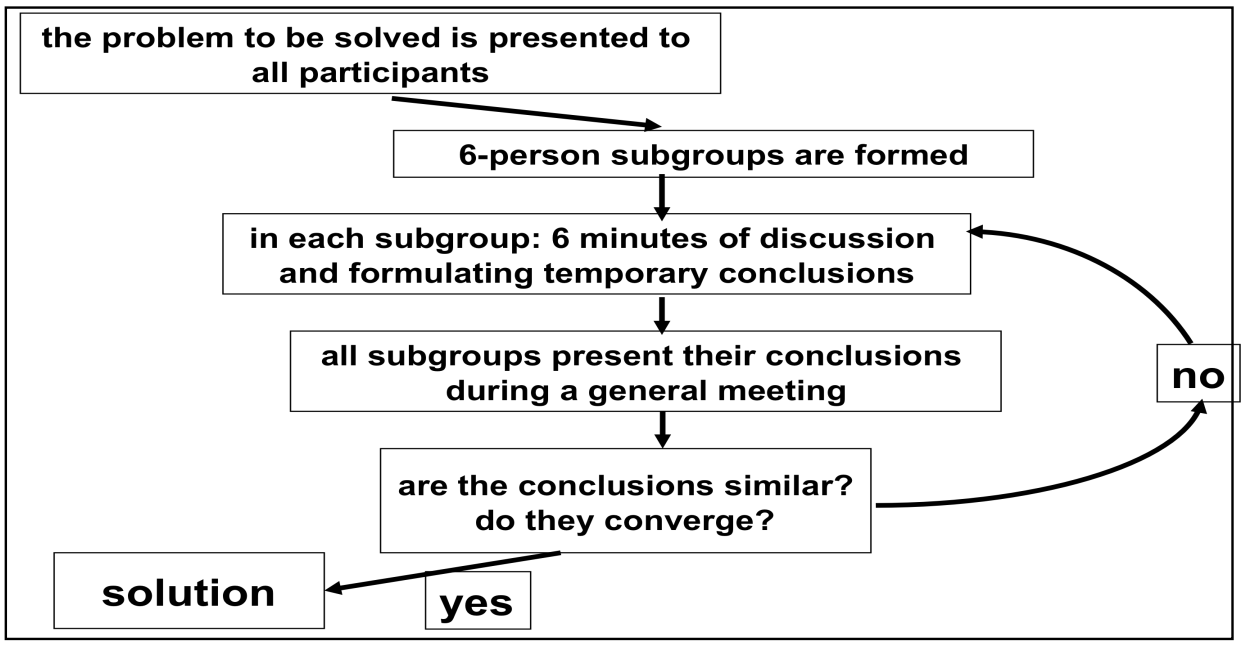

Figure 4. The flowchart illustrating stepwise convergence between ideas generated by semi-independent subgroups (also known as „Discussion 66").

Source: Own elaboration

Table 1.

A possible scenario of dynamic changes occuring during a session of the stepwise convergence method.

one common topic explained to all participants			
dividing participants into subgroups	**subgroup A**	**subgroup B**	**subgroup C**
1st round	A develops idea A1	B develops idea B1	C develops idea C1
1st forum discussion			
2nd round	ideas proposed by B are considered the best, adopted and modified A1 -> A2(B1)	ideas proposed by A are considered the best, adopted and modified B1 -> B2(A1)	ideas proposed by A are considered the best, adopted and modified C1 -> C2(A1)
2nd forum discussion			
3rd round	A develops the same idea further A1 -> A2(B1) -> A3(A2(B1))	B reverts to its original idea B1, as modified by A, and develops it further B1 -> B2(A1) -> B3(A2(B1))	C develops the same idea further C1 -> C2(A1) -> C3(C2(A1))
3rd forum discussion			
4th round	A adopts idea B3 and develops it further A1 -> A2(B1) -> A3(A2(B1)) -> A4(B3(A2(B1)))	B develops the same idea further B1 -> B2(A1) -> B3(A2(B1)) -> B4(B3(A2(B1)))	C adopts the latest idea developed by B and modifies it C1 -> C2(A1) -> C3(C2(A1)) -> C4(B3(A2(B1)))
4th forum discussion: general agreement that C4 (with modification) is better than A4 and B4			
Final decision: C4(B3(A2(B1))) (with modification)			

Source: Own elaboration

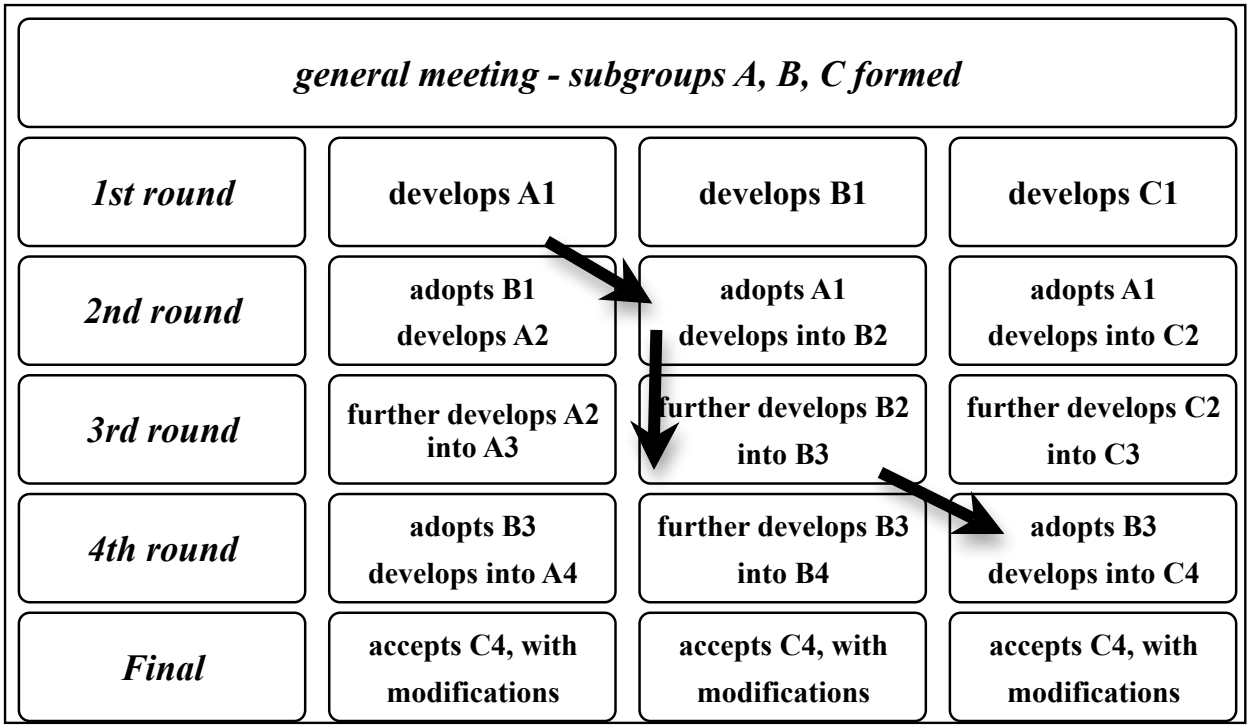

Figure 5. Stepwise convergence between ideas generated by semi-independent subgroups

Source: Own elaboration

CONCLUSIONS

Heuristic methods, if made available as e-learning tools, all acquire new levels of flexibility, which is an important component of the self-regulated learning approach to education (see Barak 2010) and of the environment conducive to innovativeness (Jasieński 2012a; Jasieński & Rzeźnik 2012). For example, they can be applied asynchronously, i.e. they allow users with conflicting schedules for participation in the same creative online session. The essence of many simple heuristic methods is that the results accumulate slowly and no one expects that the final result will appear after one formal session of creativity.

A well-designed online system will perform, more effectively than many human beings, the role of a stimulator, tactful moderator (e.g. preserving anonymity of participants, when needed; see Yong 2008) and patient collector of ideas. Members of the community (e.g. members of a laboratory or a research team, coworkers, students in the same study group etc.) are encouraged (and reminded by the system) to participate in the process, on a daily basis. Participation means both generating and submitting answers and judging them, while fulfilling recommendations with respect to anonymity and impartiality at the same time (Chang 2011).

Moreover, three major functionalities, namely data and idea visualization, social input, and enabling research would constitute major benefits of an e-learning implementation of heuristic methods (see also Batey 2012; Jasieński 2012b).

However, the main goals that remain are, of course, improving our creative fitness (Verberne 1997) and inventive ideation (Ross 2006), i.e. generation of new ideas.

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