The game of Eleusis: An entertaining simulation of the research heuristic

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ABSTRACT

Given the problematic nature of the introduction of high school students to the Research Culture, this paper deals with an analysis of these students' connections between elements of this kind of investigation and elements of an entertaining card game that simulates it – the game of Eleusis. As theoretical-methodological axis, we used Bardin's Content Analysis from the Theory of Meaningful Learning perspective. The results point to clear connections between those elements, despite some still fragile conceptual constructions. These findings were satisfactory for the problem, given the character of an advance organizer of the game for the thematic focus.

Keywords: The game of Eleusis. Heuristics. Scientific literacy. Advance organizer.

O jogo de Elêusis: uma simulação lúdica sobre a heurística da investigação científica

RESUMO

Frente à problemática de inserção de alunos de ensino médio à cultura de investigação científica, o presente trabalho trata da análise de conexões que tais alunos fizeram entre elementos deste tipo de investigação e elementos de um jogo lúdico de cartas que o simula – o Jogo de Elêusis. Para analisar as conexões realizadas pelos alunos, utilizou-se a Análise de Conteúdo de Bardin sob a luz da Teoria da Aprendizagem Significativa de Ausubel e Novak. Os resultados acusaram conexões claras entre os referidos elementos, apesar de algumas construções conceituais ainda frágeis, isto é, ainda não assimiladas devidamente como funcionais. Tais resultados se mostraram satisfatórios para com a problemática, tendo em vista o caráter de organizador prévio do Jogo para com a temática em foco.

Palavras chave: Jogo de Elêusis. Heurística. Alfabetização Científica. Organizador Prévio.

INTRODUCTION

Thinking science in a proper form, i.e. a way of thinking consistent to the consensus arising from both the methodological and epistemological academic discussion, relates to

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Recebido para publicação em 23/7/2015. Aceito, após revisão, em 27/11/2015.

the role of science education itself. As the formation of citizens, scientists or not, passes through the hands of professionals in this area, facing the stereotypes of Science that pervades common sense, in the form of classroom discussions, is an implicit task in the act of this education (CUPANI; PIETROCOLA, 2002). Teaching and learning sciences, therefore, are actions of breaking with cultural cognitive structures. As Driver et al. say, "learning science involves young people entering into a different way of thinking about and explaining the natural world" (1994). 'Different' because it is often more elaborated and uses languages (like mathematics) that are unusual in the everyday life of many cultures (PIETROCOLA, 2002). Therefore, there is a definite role to be fulfilled by the science teacher; a rigor at the level of professional scientists, as there is a commitment to training future students-citizens (PRAIA; CACHAPUZ; GIL, 2002)! What attitudes should then the Science teacher take to enable their students to build themselves a consciousness of science as close as possible to the contemporary conceptions? This is our problem.

On the one hand, some authors point out as wrong the teaching of an alleged "scientific method" as a solution to this problem. Among them, some claim that the scientific method does not begin with the observation because it is always preceded by theories that work as "lenses" to the scientists so that they may have extended their perceptions about the phenomena. They also point out that the practice is not a logical, algorithmic procedure; otherwise science would be a simple "crank-operated contraption" (MOREIRA; OSTERMANN, 1993; VALADARES, 2000). Furthermore, they point out that "there is no consensus among philosophers of science on how to better understand what scientists do, is building theories or in assessing them" (WOODCOCK, 2014). As for "The Method" itself, there are still differences regarding the number of steps, which one starts or ends the process – or if it, in fact, has an outcome in itself.

From all the provisos outlined here, there is greater clarity on the issue: we must seek to build experiences that respect the assertions, in particular, those highlighted by the mentioned works.

This paper describes an experience in this line of thinking that uses an entertaining game of cards, the Eleusis game. It is a game that is supposed to simulate scientific practice (CHARLES ROMESBURG, 1979; GARDNER, 1977), not in the stereotyped form against which those authors warn, but as a heuristic for the scientific practice, in line with George Pólya's *How to Solve It* book (1945). The game was used aiming that the students build parallels between it and the practice as an introduction, as the logic of the scientific community were not commonplace to them. Therefore, the question that guides this research is what are the connections that freshmen students of secondary public education make among the elements of the Eleusis game and scientific practice?

To analyse these connections, we used Content Analysis (BARDIN, 1977), from the perspective of the Educational Psychology of Ausubel and Novak (AUSUBEL; NOVAK; HANESIAN, 1968).

> Modern heuristic endeavors to understand the process of solving problems […]. [A] better understanding of the mental operations typically useful in solving

> problems could exert some good influence on teaching […]. The aim of heuristic is to study the methods and rules of discovery and invention. (PÓLYA, 1945, p.112, 129–130)

Pólya proposes a classroom heuristic in the form of "procedures (mental operations, moves, steps) which are typically useful in solving problems" (1945, p.172). Far from going against previous statements, that author points out: "Infallible rules of discovery leading to the solution of all possible mathematical problems would be more desirable than the philosophers' stone" (1945, p.172). Thus, the Heuristic speaks of The Scientific Method as an investigative practice, not as a 'method,' as previously discussed. As stated, it is in this line that we will work.

Although theoretical or field investigations by students can be proposed, such activities may be too advanced for high school freshmen, whose cognitive conceptual framework may at first be unsuccessful in communicating in this environment (PRAIA, 2000). Which the first action to take in this enterprise? We propose the use of a card game known as the Eleusis game.

THE GAME OF ELEUSIS

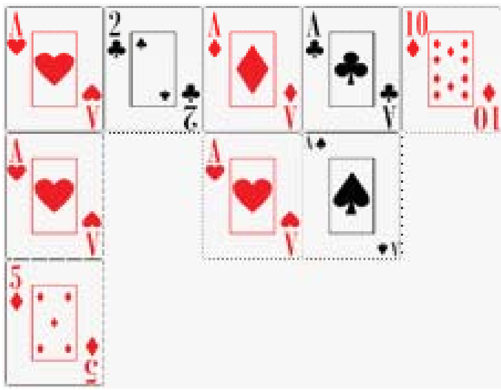
This game, created by Robert Abbott (1963) and especially publicized by Martin Gardner (1959, 1977),

> […] allows, through an entertaining experience, the understanding of the model of the scientific process that has better acceptance among scientists: the formulation of a hypothesis testable front of a problem, deducting a possible consequence amenable to experimental verification or observation, resulting in confirming or rejecting the hypothesis. (FLORSHEIM; BORGES, 1982, p.46)

This game is played by essentially two kinds of subjects: a judge and the remaining players (or groups of players). The judge formulates a secret rule on how cards can be played correctly, which the other players attempt to determine inductively. To this end, each group receives a certain number of cards at random, which go one-at-a-time on a line of cards (Figure 1). If the card follows the rule, the judge remains inert; if the card violates the rule, the judge moves it below the line of cards starting a side-line and the player receive more cards as a penalty.

For example, let the secret rule chosen by the judge be "intersperse colours one-by-one". If the first card on the table is red (say an ace of hearts), the next group should enter a black card; if they put a red card (as another ace of hearts) instead, they will observe the judge placing it below the original, concluding that the card was refused. Not knowing which the rule is, students may then risk putting another red card (five of diamonds): the judge will put it below the last one. However, after finally choosing a black card (two of clubs), they will observe the judge showing no reaction – knowing thereby that the card was accepted according to the secret rule. This illustrative example is shown in Figure 1.

FIGURE 1 – A moment during an example match.



Source: made by the authors.

It is to be noticed that the "intersperse colours one-by-one" pattern follows horizontally while subsequently repeated colours go below the line of cards as they violate the secretly pre-established rule.

Thus, after initially putting cards at random, as patterns of both errors and correct answers develop, players become able to make oral guesses at what is the rule. In the case of success, the game ends with the victory of the team. On error, depending if it is from logic or negligence, the group is rewarded or punished, respectively.

As this activity has the objective of building parallels with the scientific practice and making its elements best elucidated (CHARLES ROMESBURG, 1979), our investigative question is reinstated here: what are the connections that freshmen students of secondary public education make among the elements of the Eleusis game and scientific heuristic? To analyse such students' constructions, Ausubel and Novak's Educational Psychology was used.

If analysing connotations deals with analysing meanings that people attach to words or phrases, then, when such *meanings* are given in the classroom, one is interpreting partial buildings of individual under development; these buildings themselves are the essence of a learning process that is considered meaningful.

According to David Ausubel's constructivism, meaningful learning is the instructional interaction that allows the presentation of new concepts to the learner's cognitive structure in such a way that they become an integral part of this same structure

(PRAIA, 2000)[1]. To this end, "the most important single factor influencing learning is what the learner already knows" (AUSUBEL; NOVAK; HANESIAN, 1968, p.vi)

Within the context of meaningful learning, there are several metacognitive strategies, such as advance organizers and concept maps[2], which can catalyze its occurrence. These advance organizers are nothing but a didactic material, whose goal is to promote private cognitive networks (the students' cognitive structure) connections with new information coming from other cognitive networks (the scientific community, for example) through a particular network (the teacher). This is an introductory didactic action, which can either "awaken" prior knowledge relevant to the topic in cognitive structures or present a knowledge that is still unknown to the student audience (MOREIRA; SOUSA; SILVEIRA, 1982). Therefore, in the practice here described, the Eleusis game can be categorized as an advance organizer for scientific heuristics.

METHODS

Our investigation is configured as an essentially qualitative analysis, considering the descriptive character with which we sought to probe meanings present in students' texts. Inferences about quantitative data were not sought: they were used only in search of greater clarity of conceptual constructions that individually emerged out of the groups (as possible "consensus" of meanings).

Participants in the research were freshmen students at a regular public high school in the metropolitan area of the capital of the Brazilian state of Rio Grande do Sul. Only two weekly periods were available for the activity, which limited the number of Eleusis game matches.

Initially, the teacher presented the rules of the game[3], using the same example mentioned in the previous section to illustrate it; then the students separated themselves into two groups while the teacher acted as judge. The rules are as follows:

a) If the player's card violates the secret rule, it will be put below the card with which it disagrees (always the last one from the horizontal row) starting a sideline; if it conforms to the rule, it will be placed in the 'mainline' to the right of the last played card. This main rule of the game mechanism aims at paralleling with Science observation-phenomenon-reality interaction. Both from mistakes as from successes the students should identify patterns for building their own rules.

b) The cards can only be played after group discussion. The pedagogical purpose of this rule, added to the ones proposed by Abbott (1963; see also GARDNER,

[1] For a more comprehensive description of David Ausubel's educational psychology, the reader is referred to his book (AUSUBEL; NOVAK; HANESIAN, 1968).
[2] For further guidance on other cognitive tools within the context of Ausubel & Novak educational psychology, see (NOVAK; GOWIN, 1984).
[3] The rules that were actually followed were adapted from (GARDNER, 1977).

1977), was to inculcate teamwork, which is present in the contemporary scientific community as a whole. The intention here was to deconstruct the stereotype of a "lone scientist", as pointed out by Woodcock (2014) and observed in a survey dialog held as an introduction to these classes' school year.

c) The number of cards received after making a regular play varies according to the consistency of the card played. The function of this rule was to facilitate the parallel between the cards in the player's hand and an analysis tool, which is "enhanced" through the "bonus" resulting from a consistent card play.

d) Inconsistent plays with a severe lack of observance of the cards on the table were punished with the removal of cards from the player's hand. The purpose of this rule is the same as the previous one.

e) The judge must never give hints about the rule. With this rule, it is intended to parallel the judge with Nature, which apparently does not give hints about its mechanism; rather, it is inert and indifferent to human knowledge/science. Parallelism breaks, of course, at the end of the game when the judge is expected to announce that the group "discovered" the rule – an action that is possible in the game, but not in Nature, according to current epistemological view (CUPANI; PIETROCOLA, 2002).

After conducting the largest possible number of matches, it was proposed to the students, arranged in groups from 4 to 7 members, to answer the following single question that incited the research activity (Table 1).

TABLE 1 – Sole question in the report.

Analysing the elements and types of players, identify each one of them with the scientific practice and method, explaining the relationships between them.	
a) God and/or Nature	d) Hypothesis
b) Phenomenon	e) Probing instrument(s)
c) Scientist(s)	f) Conclusions/Law.

Source: the authors.

Thus, it was proposed an activity in which students, after the practical interaction of the Eleusis game, wrote about connections between the elements of two scenarios: the scientific practice and the game itself. It was decided to analyse these connections via Content Analysis according to Bardin (1977).

Content analysis, according to Bardin, does not refer to a technique in itself, but to a variety of investigations aimed at scanning/probing a group of documents (corpus), whether written or oral, so that meanings become subjectively explicit to the investigator.

It is a scanning of connotations, subjectively expressed or implied in expressions from an individual or a collectivity (BARDIN, 1977).

Since the goal was to identify the logical connections between a heuristic model of the Scientific Method and a card game that simulates it, two reports were excluded from a group of 15 reports from four classes[4], as they were incomplete. Thus, the corpus of this content analysis includes 13 reports from four different classes. It was decided not to make assumptions a priori because a phenomenological attitude in the analysis was intended (SOUZA, 1999).

The enumeration by mere presence was chosen as *analysis technique*, but without establishing a priori categorizations. The *registration units* were the connective paragraphs (answers to a certain point the question in Table 1) built by the students; the *context units* were the reports as a whole, which related responses to each other. The adopted *enumeration rule* was that of presence. The *dimensions of analysis* were the points of Table 1 themselves, plus two overall dimensions for each point:

- *"Relation," which sustains the connections between elements of scientific practice with elements of the game, and*
- *"Argument," which supports the students' whys and justifications to the connections in presented in "Relation."*

Besides these, other dimensions emerged from the analysis of the responses at different points.

DISCUSSION

The analysis of students' connections referring to the item (a) (God and/or Nature) allowed for the precise identification of the dimensions set out above "Ratio" and "Argument." It also allowed for the distinction (either implicit or explicit) between the concepts "Nature" and "God" as well as their merging – the latter possibly influenced by the union ("and/or") between the entries in the text of item (a). Such merging had the educational purpose of enabling a free interpretation of this element regardless of the teacher's beliefs and/or student(s), and indeed a few groups distinguished these concepts. Due to this fact, relations "Nature-", "Nature/God-" and "God-" were also counted in an aggregated manner simply as "(a)" in the axis/dimension "ratio" as "Relations with Judge". Distinctions were analysed as another dimension. In Table 2 the counting is exhibited for more explicit generalities and details.

[4] As observed and discussed in the classroom with the students of the group, this incompleteness was caused from their lack of motivation in participating in the practice.

TABLE 2 – Explanation of axes and counts related to the element (a) God and/or nature.

Most frequent relation of element (a): Judge, 11 groups		
Most frequent argument in the Relation to Judge: - Organizes/defines/edits/knows/creates/elaborates the rule/sequence = 9 groups		**More frequent distinction in the Relation to Judge:** - God-Nature implicitly = 4 - God-Nature explicitly = 1
Forms of the relation of element (a) with Judge:	*Arguments of the connection (a) with Judge for each different form:*	*Distinctions of the connection (a) with Judge for each different form:*
Form 1: God/Nature-Judge = 7 groups	*Arguments of Form 1:* Organizes/defines/edits/knows/creates/elaborates the rule/sequence = 5 groups - Commands the move = 1 group - Studies what goes on in the game = 1 group	[n/a]
Forma 2: God-Judge = 2 groups	*Arguments of Form 2:* - Organizes/defines/edits/knows/creates/elaborates the rule/sequence = 1 group Not a focus of study = 1 group	- God-Nature explicitly = 1 group - *God-Nature implicitly = 1 group
Forma 3: Nature-Judge = 2 groups	*Arguments of Form 3:* - Organizes/defines/edits/knows/creates/elaborates the rule/sequence = 1 group - Centre of the game = 1 group - Origin of the phenomenon = 1 group - Makes the game = 1 group	- God-Nature implicitly = 2 groups
Other relations: 2 groups		
Relation to element (a):	*Arguments for each connection with (a):*	*Distinctions of each connection with (a):*
Nature with Players = 1 group	- Interaction = 1 group	- God-Nature implicitly = 1 group
Nature with Cards on the table = 1 grouP	- Focus of study = 1 group	- God-Nature explicitly = 1 group

Source: the authors.

The "Distinction" axis here was built due to the non-fusion "God/Nature" by the students. The distinctions, one explicit (group III) and four implicit, can have three possible origins not mutually exclusive. The first one would be a student religious belief in not fusing similarities between "God" and "Nature". Another one is the assertion raised in class that, by yielding itself to Popper's principle of falsifiability, the existence of God is not treatable by Science. Finally, the didactic addiction, explained by (AUSUBEL; NOVAK; HANESIAN, 1968), that teachers traditionally impinge automatic/mechanical learning by requiring verbatim transcripts of whole words or propositions.

Furthermore, the analysis of this element also made explicit that the majority (9/13 or 69.2%) *associated God/Nature to Judge from both entities* ***transcending*** *the game itself*.

On the other hand, the analytical reading concerning the item (b) ("Phenomenon") shows marks of:

a) <u>A conceptual shock about the signifier "Phenomenon"</u>: the scientific denotation of the entry "phenomenon", although intrinsically complex (given the magnitude and depth of study that Phenomenology requires), in simplified terms, is "that which manifests itself," a noun/object, therefore. However, there is a common connotation assigned to the entry in question as "what stands out", as it is attributed to sports or musical celebrities. Although the close relationship between scientific connotation and denotation, it was found to be close enough to cause said shock.

b) <u>The still restricted construction of the meaning of "Phenomenon"</u>: the great depreciation is justified by the lack of arguments on the relationship (or on itself) in the connections made by some groups.

When making explicit these two points, it is understood to mean another mark of the analysis of this element (when looking comprehensively at all exhibits/connections). It is the mark of the distinct plurality between connections and even between arguments, which, from our point of view, annulled any general categorization/scaling, both on the "Relationship" axis and, especially, in the "Argument" axis, which is why it was decided not to build any categorization table.

TABLE 3 – Explanation of the axes and related counts to the element (c) (“Scientist”).

Most frequent relation of element (c): Player(s)/participant(s), 12 groups	
Arguments referring to the connection of (c) with “Player(s)”	**Actions referring to the connection of (c) com “Player(s) /participant(s)” in general**
Arguments referring to rule/conclusion: 8 groups - Discover/find the rule/sequence/formula/answer = 6 groups - Arrive at/give conclusions = 2 groups	- Arrive at/discover/find the rule/answer/sequence/ conclusion = 4 groups - Edit/elaborate hypothesis/play = 2 groups - Know the essence of the game/discover what the judge thinks = 1 group
Arguments referring to play/hypothesis: 6 groups - Test/crate/study/propose/discover hypothesis(es) = 4 groups - Guess/play/dictate actions/plays = 2 groups	
Arguments referring to the analysis in itself: 3 groups - Study the cards = 2 groups - Analyse/study the game = 1 group	
Arguments referring to the involvement process-subject: 1 group: *- Influence themselves by the problem = 1 group*	

Other relations of the element (c): 1 group		
Alternatively relation:	*Referent argument:*	*Referent action:*
Law = 1 group	Organizes hypothesis + prevision + experience	[No finality denotation or connotation].

Source: elaborated by the authors.

The obviousness mentioned above is quantified by the 12 groups (92.3%) who have connected Scientist-Player; of these, 8 (66.7%) evoked argument concerning the rule or conclusion and 6 of the 12 (50.0%) the play/hypothesis. The construction of the dimension/axis “Actions” appears in 7 of the 12 connections/reports (58.3%). 4 of them refer to the “end as an end in itself” (i.e., looking at the completion/rule as an end in itself); 2 of the 7 speak of the objectification of the process itself when mentioning the construction of the hypothesis/play as an end to be achieved; and only one group writes about uncover/discover.

The analysis of the item d) (“Hypothesis”) is marked by the relation hypothesis- play and by the lack of arguments to explain the relation in some reports. In Table 4, scores of the two dimensions numerically more observable in that table are made explicit. Notice that the distinction between the entries chosen to express the connection is required through the axis “Argument.”

TABLE 4 – Explanation of the axes and counts related to the element (d) (“Hypothesis”).

Relations with the element (d)	Argument of each relation
Relation 1: argued under evocation of rigor/ coherence = 4 groups - Guess = 2 groups - Logical play/judgment/opinion = 1 group - Suggestion = 1 group	- Take a right conclusion = 2 groups - Has precise ground = 1 group - [Maturable mutability] = 1 group - Reasoning test [right+wrong] = 1 group
Relation 2: argued as “attempt to discover”= 2 groups - Guess = 1 group - Opinion = 1 group	- Attempt to discovery/unveiling = 2 groups
Relations without argumentation = 7 groups - Guess/opinion/ what is thought = 4 groups - Play/attempt/play = 3 groups	

Source: The authors.

With the categorizations of postings described in Table 4, it is noted that relations that expressed argument on accuracy/logical consistency make up 4 from the 13 reports (30.8%); of these, half (2/13 or 15.4%) of accounting was found with argument alleging attempted unveiling. It was also noted the absence of argument/explanation in 7 of the 13 reports (53.8%), although they have connected entities of scientific practice with the game. Above all, it is noted that all the answers referred to the logical expression of the player towards the answer.

The content analysis of item (e) (“Probing Instrument”) allows the emergence of a dichotomic dimension of the distinction (or not) between “cards in hand” and “cards on the table.” It also emerges the relational unanimity among the entities “Instrument” and “cards” and the uniqueness of the group IX in indirectly identifying the sense and reason as an instrument. Table 5 accounts and clarifies a few details.

TABLE 5 – Explanation of axes and counts related to the element (e) Probing instrument.

Most frequent relation of element (e): Cards = 13 groups (unanimous)	
Arguments used in the relation: That with what one thinks = 6 (*) That with one interacts/operates = 3 (**) Without arguments (or unfathomable /vague) = 4 (***)	
Forms of the relation with the cards:	*Arguments used in each form of relation:* *(the number of asterisks refers to how these arguments nested under the previous thread count)*
Form 1: with the cards in hand = 6 groups	** - one interacts with: 2 groups * - helps the discovery: 1 group ** - [subject to operation]: 1 group *** - important component: 1 group *** - none: 1 group
Form 2: with the cards indistinctly = 6 groups	* - through which one draws conclusions: 2 groups * - helps to discover [essence] of the game: 1 group * - is analysed with: 1 group * - with which we discover the rule: 1 group *** - none: 1 group
Forma 3: cards on table = 1 group	*** - research material: 1 group
Relation with sense and reason: 1 group	
Argument used in the relation: is analysed with	

Source: The authors.

From this unanimity, 6 (46.1%) described the instrument as “that with what you think”, 3 (23.1%) “that with you interacts/operates”, and 4 do not use arguments or use vague ones (30.8%).

Finally, concerning the element (f) (“Conclusion/Law “), there is a lack of relation to any element of the game (4/13 or 30.8%) or argument to sustain the relation (5 out of 9 who did, or 55.6%) – totalling 9 of 13 reports (69.2%) without argument. The counts are shown in Table 5 and inferences about the connections made by the students soon after it.

TABLE 6 – Explanation of axes and counts related to the element (f) Conclusion/Law.

Most frequent relation of element (f): conclusion of an undertaking = 7 groups	
Indicator of the relation with conclusion of undertaking	*Arguments used in the relation: (independently of form)*
Form 1: Rule/grasp the rule = 5 groups Form 2: Right answer/verdict of the judge = 2 groups Form 3: What is hidden in the sequence = 1 [This report also relates to "hit"].	- [Non-existent/unfathomable] = 5 groups - One arrives at it through guess/hypothesis = 1 group - One tries to discover/decipher it = 1 group
Other relations with element (f): 2 groups	
Other forms of relation with element (f):	*Arguments referring to each form:*
Form 1: With final and combined thinking ("environmental/contextual" element to the game) = 1 group	[None]
Form 2: Play that follows pattern = 1 group	Follows game pattern.
Absence of relations with element (f): 4 groups	
Lack of argument = 9 groups, of which - together with the absence of relation = 4 groups - together with any relation = 5 groups	

Source: The authors.

From Table 6, one also reads that 7 of the 13 reports (53.8%) connected "Conclusion" to "conclusion of the undertaking" (game-research). However, 4 out of the 7 had no argument and 1 did not let clear his explanation (adding up to 5/7 or 71.4%).

Above all, there was no reference signal to the understanding that there is no effective end game, even if having been some matches, in all classes, in which no group deduced the rule, despite coherent suggestions that could have built it.

As inferences have been made before, in this section, they will be in summary form to facilitate discussions with other investigative probes with students about the Nature of Science theme.

First, the analysis of the connections made with the element (a) explained that the majority (9/13 or 69.2%) associated "God/Nature" to "Judge" because both entities **transcend** the game itself: the Judge performs actions above the players, they do not have access to nor can replicate them (organizes/defines/says/knows/creates/produces the rule). The analysis of the element (b) indicates that 12 groups (92.3%) connected Scientist to the Player, and 8/12 (66.7% of them) on the grounds for the rule or conclusion and 6/12 (50.0 %) to play/hypothesis, i.e., cognitive/logical-mental actions. Taking this data as private premises, associated with the general one that transcendence is not proper to the human being, it can be deduced that it has been built in these students the understanding that *science is above all human (while not transcendent work) and, therefore, faulty and* *developable* because the "rules of nature" are apart from the knowledge of scientists (players).

A second point that stands out from the analysis is the diffuse characteristic of the connections built in element (b) ("Phenomenon"). Two interpretations of such diffuse character showed up: the conceptual shock on the signifier "phenomenon" and the restricted construction of its scientific significance, given the absence of proposed connection. *This points both the failure of the presentations that preceded the game about the construction of this concept, the importance of such presentations as a basis for the connections to be made during the game.*

Still another point on the element "Scientist" is explicit. In its analysis, the dimension "Objectives" (of the scientist) had 7 goals of the practice. 4 of them point to a look of "conclusion/rule" as an end in itself while the other 2 refer to the objectification of the process itself when they mention the construction of the hypothesis/bid as a goal to be achieved. *These six groups that exhibited such purposes allow us to realize the closed character of scientific research with which the students conceived it after the game, an implicit point against it in its simulation function of the scientific method.*

In analysing the responses for the "Hypothesis" element, it was noted that the relations that expressed argumentation on accuracy/logical consistency added up to 4 from the 13 (30.8%); in half of them it was found arguments alleging "an attempt to the unveiling." The first mentioned form of argumentation may point to a clear understanding of the need for some rigor in the construction of reasoning; the second, in turn, may indicate the understanding of scientific cognitive practice (hypothesis) as "*rational effort/ action of research*." It was also noted the absence of argument/explanation 7 reports (53.8%), although they have connected entities of scientific practice with the game. The lack of argument may come from a still vague conceptual construction of the student (a connotation, therefore): a vague understanding of the scientific idea of 'hypothesis' (a denotation) precluded any argument that supports the presented relationship; this argument could not be induced, however, any association with the concept that the students have about the terms chosen to build the connection, such as guess, play, and opinion. Thus, the lack of reasoning must be a sign of the idea of "hypothesis" not having being properly assimilated to the cognitive structure, that is, such an idea was not appropriated by students as a functional/useful concept (AUSUBEL; NOVAK; HANESIAN, 1968).

It also emerges from the analysis the connective unanimity between the entities "Instrument" and "Cards" and the singularity of the group IX in indirectly identifying the sense and reason as tools. This unanimity, however, indicates a slightly different relation to the instrument: "think with" and "operate with" a cognitive and motor dichotomy. However, the fact that the 4 groups that do not use arguments, or are vague in formulating them, may come from the little contact that these students generally had with the theme, which could be read from interactions with them later on this investigation.

As a final point, the element (f) "Conclusion", reading points out, in some reports, its interpretation as that typical of schoolwork, such as "with this work I learned that ..." rather than of the scientific practice and the game. It is also noted the lack, sometimes of any element of the game (4/13 or 30.8%), sometimes of arguments that sustain the established relation (5 of 9 who did, or 55.6%) − a total of 9 of 13 reports (69.2%) without argument. The origin of these absences may lie in the highlighted confusion, or in the same possible sources of the element "Hypothesis," namely in the *vague concept construction-connotative* of "Conclusion" and/or "Law" or in a *collective consensus obviousness* of what it/they is (are).

Finally, in Table 5 one reads that 53.8% connected the "Conclusion" element to "finalizing the game/research"; of which 71.4% had no argument or not made clear their explanation. The group that got "Conclusion" as a "final thought and set" may have explained the fixation that science is a collective enterprise.

Above all, in general, the inferences made on the reports point to clear connections between some elements: "Scientist" and "Player" (92%), "God/Nature" and "Judge" (84%), "Probing Instrument" and "Cards" (100%). The minutiae (here omitted) of these general data allow one to induce that some groups (69%) understood Nature as transcending the scientists, a relevant epistemological relationship. Furthermore, it became remarkable the identification of "Probing Instruments" as a cognitive tool "that which it thinks with" (46%) and "which they interact with" (23%).

However, the data also allowed us to verify that the conceptual construction was carried unstable for some significant. The "Hypothesis" element, for example, although all (100%) designing it as a logical expression toward the answer, the majority (54%) was unable to argue about it. The analysis of significant connections with the "Phenomenon", in turn, did not generate data that would allow categorizations (the answers were rather singular). These results, however, were expected, according to Ausubel and Novak's Educational Psychology.

Meaningful learning is a complex process that requires life span invested in several interactions to feed the cognitive structure; meaningful learning does not occur, it is occurring (MOREIRA, 2005). With the Eleusis game working as a previous organizer, the concepts "hypothesis" and "phenomenon", being new to most students (as found in previous dialogues to practice), have not had adequate livingness for stabilization in the cognitive network. It is worth remembering that school actions are the sum of the *few, limited and perhaps unique* experiences that some students have in contact with the scientific practice. These concepts, even if observed fragile at that moment, became useful information for later didactic teacher action.

As for the problems observed during the teaching experience, it should be highlighted the short time available to students to play (about a maximum of four periods distributed in two weeks) and the big groups formed to play. Both problems are related: a low persistence in keeping the focus on activity on the part of some students was a vehicle to the dispersion of the waste of available time in extracurricular chats or even the use of the cards for other games. The small development of argumentative skill is also a point against at the time of evaluation: connections or arguments left blank inhibited the teacher of a more accurate analysis, much the "written silence" can point to educational failure. It is strongly recommended that the problems identified to be taken into account in future activities.

After all, it was considered that the practice was successful as a previous organizer of scientific research heuristic considering the meanings identified in the analysis.

CONCLUSION

In connection with our initial problem of students' insertion in the scientific and investigative heuristics, and our guiding question about the connections that these students would make between elements of heuristics and elements of Eleusis game, the results were satisfactory. Those connections were identified as clear and consensual by a significant proportion of students, and the fragile quality of certain concepts is understandable when taking into account the prerequisite of cognitive structures of students.

These results allow us to realize the closed character of scientific research with which the students conceived it after the game, an implicit point against it in its simulation function of the scientific method.

As for the problems of time available to students, the size of the groups formed to play and the weak development of argumentative skills, we recommend that they are taken into account in future activities.

It is emphasized, again, the character (I) introductory and (II) heuristic of Eleusis game, so that there is neither didactic frustrations face the restricted connections that arise nor confirmations of harmful stereotypes to the students scientific training. It is recommended too (as was later done with the students) that such practice be succeeded by real problems of investigations so that skills and expertise concerning scientific practice are adequately developed.

ACKNOWLEDGEMENTS

The authors acknowledge the support of CAPES and FAPERGS, without which there would not be the possibility of this investigation.

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