USING CRITICAL SYSTEMS THINKING TO PROMOTE REFLEXIVITY ON AN ENGINEERING SACROSANCT CONCEPT

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ABSTRACT

This paper presents a systemic intervention in which a group of researchers and engineering students used critical systems thinking ideas to promote reflexivity on a basic concept that underlies engineering practice: efficiency. In particular we explored a situation in which students had to deal simultaneously with issues of efficiency and justice. Engineering students are frequently trained to design efficient systems or to improve the efficiency of already existing systems. Although engineering and economic efficiency are not the same, young engineering students tend to equate and value both of them. However, within many contexts efficiency is not the only relevant criteria for judging among different alternative solutions to engineering problems. Justice and other ethical considerations are also frequently relevant. Not all efficient technical solutions are also the most fair, and vice versa. In this paper we describe a research inquiry in which a group of engineering students were invited to choose among diverse solutions involving issues of justice and efficiency. Based on the work of a group of scholars such as John Rawls, John Nash, Robert Aumann, and Howard Raiffa, the students explored different conceptions of justice as well as their relationships with efficiency. During this process that involved both individual and collective work, we found evidence that the students became engaged in uncovering and questioning their ways of thinking and behaving, as well as their moral frameworks. Initially we found a tendency among engineering students to be unwilling to deviate from the solutions that involve Pareto efficiency, to give priority to efficiency over justice, to understand justice only within the context of efficiency, as well as to experience difficulties in developing rational arguments to reach rationally justifiable conclusions on issues of justice and efficiency. The research revealed that senior undergraduate and master engineering students frequently experience a substantial difficulty in arguing coherently in debates about practical rationality, something that is in stark contrast with their good ability to deal with technical issues and mathematical calculations. At the beginning of the experiment disputed questions related to justice and efficiency were frequently treated not as a matter of rational enquiry and justification, but as a problem of personal opinions and unarticulated presuppositions that were relegated to the realm of irrational acts of belief. The use of boundary critique and several critical systems thinking tools contributed to change the way engineering students made and justify their choices among competing conceptions of justice, and to develop a new notion on how to reach a balance between efficiency and justice. The discussion helped students to reflect on wider issues that involved their role in issues of social justice in their society. The changes that students experienced were not the result of the researchers' intentions to convince the students of making some particular choices, but of a dialogical rather than a monological approach to ethical issues and practical rationality.

This dialogical approach involved the exploration of different alternative boundary judgements that promote reflexivity on what and whose views are included in or excluded from analysis. Students were able to understand that different ethical choices result from choosing diverse boundary judgements.

Keywords: boundary critique; critical systems thinking; reflexivity; practical reason; efficiency; justice; ethics; instrumental reason; systemic intervention; Pareto efficiency; Nash equilibrium; critical systems heuristics.

INTRODUCTION

In general terms, engineering students tend to associate efficiency as the most appropriate concept underlying a solution of a distribution problem between different actors, that is why we conducted an experiment that gave us a wider comprehension of the ethical bases related to a decision or a choice and to truly identify if the efficiency concept underlies in a wide range of decision making. To do so, we designed and conducted an experiment in three different faces applied to the same group of students throughout a negotiation and system thinking course. Two of the three faces of the experiment consisted of a survey that was also divided in two parts that included a set of multiple choice questions with a justification section over situations that involved two or three negotiators and a theoretical section that led to the selection of different solutions based on theories presented by recognized authors. The third face of the experiment required a discussion in small groups regarding the underlying concepts that determined the selection of a particular option.

Based on the results of the different phases of the experiment and some system thinking concepts related to boundary judgements, boundary critique and reflexivity we were able to establish general traits in the behaviour and the decision making processes of the students. In general terms, it turns out that there is no such thing as a reflexivity process as such in a decision making process, but this is more related to biases generated by the availability of information and what is to be taken into account in the decision process.

THEORETICAL FRAMEWORK

Critical Systems Thinking and Boundary Critique

System thinking involves reflection on the boundaries of inclusion and exclusion. When we think about systems we identify boundaries associated with those systems. This identification of boundaries determines what is to be included, or excluded from, the analysis associated with a system (Midgley, 2000).

Critical systems thinking (CST), a systemic research perspective, has been understood in diverse ways. Several researchers have described it as including three main themes: critical reflexivity, improvement and pluralism (see Jackson 2000; Midgley 2000; Ulrich 2003). This paper takes advantage of these themes. In this section we explain these themes and introduce the notion of boundary critique.

Critique involves reflexivity on knowledge and its limits, as well as on the way we relate to others. It emphasizes the importance of reflecting critically on systems boundaries (boundary critique), an activity that promotes our understanding of the ethical consequences of different possible actions (Midgley, 2002). Reflexivity should involve questioning and investigating how we might contribute to the *construction* of social and organizational realities, how we construct our actions and being in the world, and how the I approaches the Other (Pinzon-Salcedo, 2002). Reflexivity implies uncovering and questioning the basic assumptions that we make and that inspire our practices. It demands questioning our preferred points of view (Flood and Romm, 1996), moral frameworks, actions and practices. It unveils new forms of knowledge and constitutes an important element in the conception of internal and external transformations (Cunliffe and Jun, 2002). Reflexivity involves questioning the boundaries of knowledge (Midgley, 2000). Self-reflexivity implies uncovering and questioning our ways of thinking and behaving.

Theoretical as well as methodological pluralism are considered relevant in CST. By changing boundaries we modify understandings and hence each boundary may insinuate a different theory. On the other hand, each theory favours some particular boundary judgements (Midgley, 2000). Because methods and methodologies incorporate different theoretical assumptions, methodological pluralism is also relevant. Decisions among theories indicate which methodological choices might be appropriate. In turn, methodological selections suggest different theoretical and boundary judgements.

Improvement depends on the boundary judgements people use (Churchman, 1970). Because different people make different boundary judgements, what looks as improvement to someone may not look as improvement to somebody else who is making a different boundary judgement. Improvement depends on the observer. What appears as improvement when boundary A is considered may not seem improvement at all when boundary B is considered. Improvement is related to *what* and *who* is involved in constructing each particular vision of improvement (Midgley, 1995). Thus, improvement can only be defined locally and temporarily (Midgley, 2000). Because improvement can only be defined locally, choice is locally decidable. Nonetheless, choice has to be coherent and widely informed in order to be meaningful (see also Flood and Romm, 1996).

Boundary judgments are judgments about what is to be included in, marginalized by or excluded from analysis and designs (Midgley 2000). They "define the boundaries of the *reference system* to which a proposition refers and for which it is valid" (Ulrich 2003: 333). 'Boundary critique' attempts to be a rigorous effort of handling boundary judgments critically (Ulrich 2005). The boundaries of a system are personal or social constructs that establish the limits of the knowledge and the people who should be considered pertinent in an analysis. When studying a social system, altering the systems boundaries changes who may be legitimately regarded as a decision maker (Churchman 1970). In brief, identifying systems boundaries determines *what* knowledge is considered relevant and *who* may propose that knowledge (Midgley 2000).

Boundary Critique and Marginalization

By excluding critique we may end up considering some systems boundaries as absolute and unquestionable. This may hamper the examination of potentially inappropriate assumptions and behaviours. Therefore, systems thinking should involve critique. Critique demands a reflection on the implications of adopting different alternative boundary judgments (Churchman 1979; Ulrich 1983, 2003; Midgley 1992). It also demands, from the practitioner, a continuous effort to reflect on the holistic, normative, and empirical foundations of his assertions (*i.e.* boundary judgments) (Ulrich 2003) and actions. He should make transparent to himself "and to others the value assumptions underlying practical judgements, rather than concealing them behind a veil of ignorance" (Ulrich 1983: 20).

We assume that the way issues are perceived and what actions are taken depends on where boundaries are constructed and what moral frameworks guide that construction (Churchman, 1970; Ulrich, 1983; Fuenmayor, 1990; Midgley, 1992b, 2000). Choosing any specific system boundary affects the ethical stance taken (Ulrich, 1983; Midgley, 1992b). The latter also affects the selection of boundaries (see Figure 1). Hence, to select a boundary is an ethical choice.

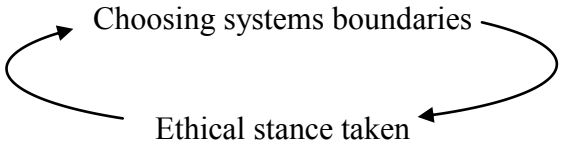

Figure 1. Systems boundaries and ethics

Fostering reflexivity on boundary judgments helps in deciding about issues of inclusion, exclusion, and marginalization. When we draw the boundaries of a system, we can look for grey areas in which marginal elements lie (Midgley 1992). The latter are elements that are neither fully included in nor excluded from the definition of the system. They are usually recognized as being relevant in some sense to the system under consideration, but they are not taken as being within the system's primary boundary (see Figure 2). The identification of a marginalized element involves the recognition of an alternative system boundary (a secondary boundary). The marginal area can be recognized only with respect to this secondary boundary, because otherwise we would lack any way to distinguish what is marginal (though probably initially hidden) from what is excluded (Midgley 1992).

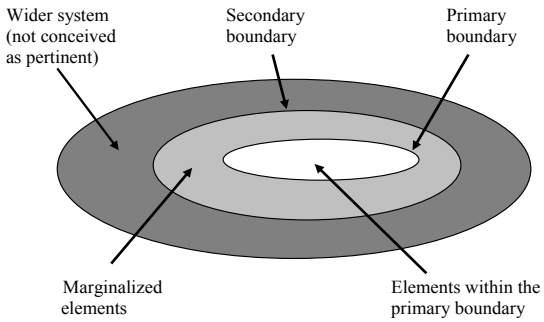

Figure 2. Marginalization (based on Midgley 1992: 7)

People's boundary judgments may come into conflict. When this happens marginal elements may be valued or devalued (borrowing terminology from anthropological studies, Midgley 1992, calls 'sacred' or 'profane' the status of the valued and devalued elements). When marginal elements are considered 'profane', the primary boundary is taken as the main reference point for decision making. In this case marginal elements are devalued and the secondary boundary is ignored or disregarded. When marginal elements are considered important they are regarded as 'sacred' and the secondary boundary is reinforced while the ethic that emerges from it receives priority. This usually involves a social process (represented in Figure 3).

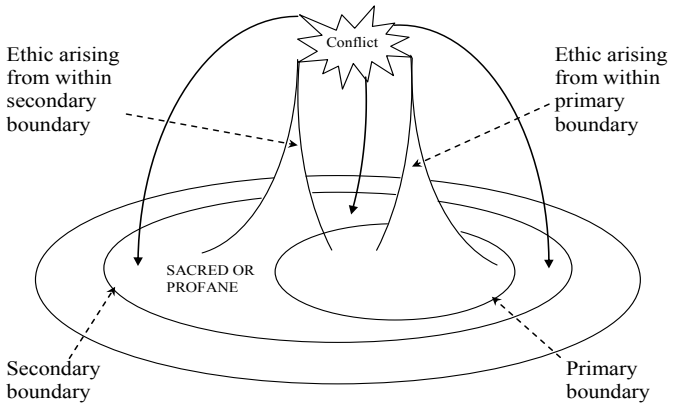

Figure 3. Marginalization, conflict and ethics (adapted from Midgley 1992: 12)

Conflicting ethics may arise from two alternative boundaries (see Figure 3). Moreover, conflicts around ethics that take place at a local level (for instance, between two parties) can frequently be linked to much wider struggles between competing discourses, although this is not represented in Figure 3 to preserve its intelligibility. Additionally, power relations, interests, knowledge and the subjective perspectives of actors might also affect the evolution of processes of marginalization (see Lax and Sebenius 1986; Yolles 2001).

A stakeholders or parties consensus on boundaries may be the result of undetected processes of marginalization and conflict (Midgley 2000). Hence, consensus should not be the automatic stopping point for critical inquiry about systems boundaries.

Pinzón-Salcedo (2002) further developed Midgley (2000) and Yolles (2001) aforementioned models (see Figure 4). Stakeholders may agree on some issues, be independent in relation to other issues, and disagree on a third group of issues. The overlapping area included by both stakeholders within their primary boundaries represents those concerns that both stakeholders want to address. The two overlapping marginal areas (outside both primary boundaries) include concerns that both parties want to marginalize. The independent or non-overlapping marginal areas represent issues considered by one party as marginal, but which are excluded from the other party's considerations. The other areas within the secondary boundaries refer to issues that constitute an important concern for one stakeholder, but which the other stakeholder either wants to marginalize or simply ignores.

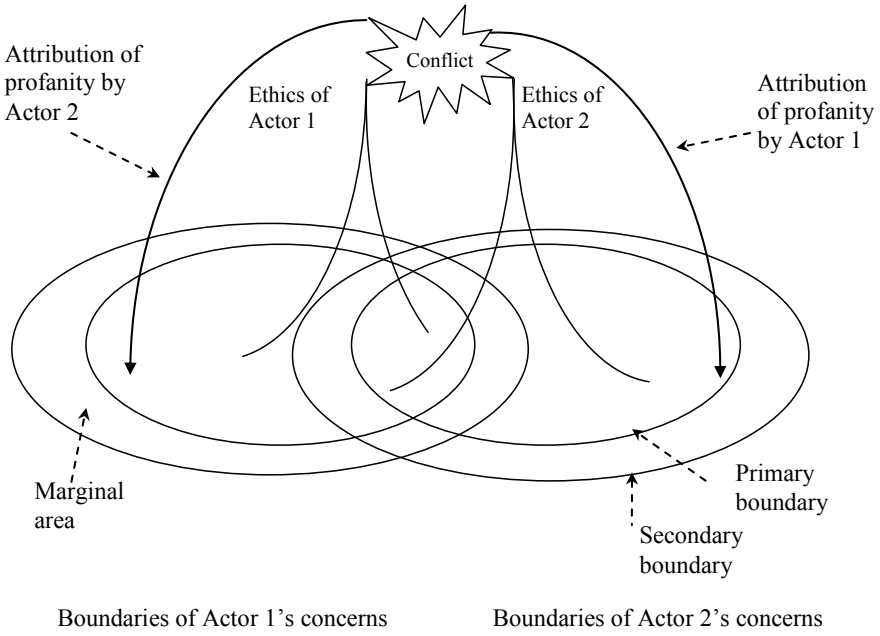

Figure 4. Marginalization and overlapping stakeholders' concerns (adapted from Pinzon-Salcedo 2002: 88)

One alternative for practicing boundary critique is using Ulrich's critical systems heuristics (Ulrich, 1983). Ulrich developed a set of questions that might be used to reflect about what a system currently is and what it ought to be. Based on Ulrich's proposal we put forward as part of our intervention questions that the students answered during the research process.

Efficiency and Pareto Efficient Frontier

In the practice of engineering, solutions and efficient designs are usually sought, that is, solutions that allow us to obtain the maximum possible results with minimal use of inputs

or resources such as raw materials, effort, time, money, energy, etc. If we consider the design or the solution as a system, we might think that it has inputs and outputs. In this case an improvement in productivity can be achieved if we increase one of the outputs of the system without reducing any of the other desirable outputs using the same inputs (we can call this an "improvement of outputs"). But we can also achieve increased efficiency through "input improvement" if we keep the same system outputs while using a minor amount of at least one input, and nothing more of the other entries. Although engineers talk about efficiency quite often, this is done in a colloquial sense more than in a technical one, as if they were talking in an informal and relaxed manner. That is why it is common to see engineers concerned about systematically reducing the resources used in their solutions, while leaving aside a rigorous concern with maximizing results.

In the field of economics, efficiency refers to the maximization of value. However, economists do not refer to the technical efficiency. While for engineers the most efficient car is the one that can travel as many kilometers with a minimum volume of gasoline, the economist does not consider gasoline as the only scarce resource to take into account. It may be favorable to spend more gasoline if it allows us to have a greater amount of other assets that we value most such as safety, comfort, acceleration or large trunk space (Galles, 2008). What an individual values depends on its preferences and circumstances. In microeconomics an efficient company is one that produces maximum results in the shortest time, and has the ability to maintain this performance over time.

In interactive games in which there are at least two players, we also refer of the concept of efficient frontier or Pareto optimal frontier. Suppose two individuals, Mary and James, are trying to reach an agreement. They contemplate various options to generate different utilities. For example, option A (see Figure 5) involves a small utility for both, whereas Option B involves greater utility for Mary than the one given to James. Meanwhile, the option C represents a better utility for James that for Mary.

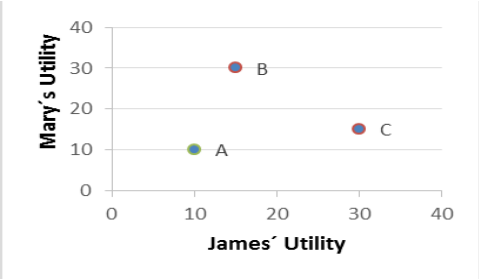

Figure 5. Joint Utilities

If Mary and James continue to explore other options, it is feasible for them to discover a multiplicity of results that have been represented by the area below the curve in Figure 6. In this figure we can see a boundary towards the northeast. Of course, an agreement on this boundary, as D, is better for both negotiators than the agreement on A. However, this option is not better than the agreements B and C for each negotiator respectively. The northeast boundary is known as Pareto Efficient Frontier or Pareto Frontier. It is not possible to improve the utility of one of the negotiators without worsening simultaneously the utility of the counterpart by moving over the boundary. Although, this

is not true for all the points of the shaded area in Figure 6. For example, with respect to the point A it is possible to improve the utility for both of the negotiators moving to the point D.

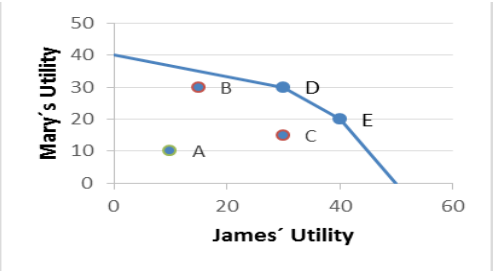

Figure 6. Pareto Frontier

All points on the Efficient Frontier, as D and E, are considered "output efficient", that is why it is not possible to choose among them from the efficiency perspective. All the points are efficient even though some generate more profits for Mary and others for James. Now, in order to choose between these options, it is possible to add the notion of preference by adding a set of indifference curves which are smooth curves convex to the origin such as the ones shown in Figure 7. The indifference curves for social welfare functions are usually represented this way. The shape of the curves suggests that as one of the two agents (James and Mary) earns more than the other, the greatest benefits for the agent that increases its earnings are less valuable from a social point of view.

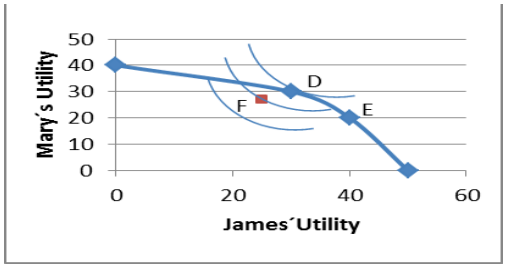

Figure 7. Indifference Curves and the Pareto Frontier

By looking at Figure 7 it is possible to see that the point D is in a higher and better indifference curve than the point E. From every point on the Pareto Efficient Frontier, point D is the most "efficient in terms of utility " ("utility efficient") . While the point E is "output efficient" and point F is not, the point F is in a superior indifference curve than that in which the point E is. Even though F is not efficient and E is, this does not imply that E is an improvement over F or greater than F; F is in a better indifference curve than E.

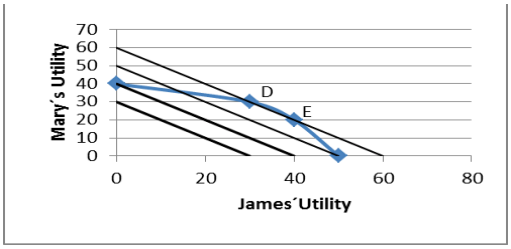

Figure 8. Indifference curves from an utilitarian perspective.

A classic utilitarian would only worry for the total sum of the utility for the two (James and Mary) being indifferent about how this total sum is distributed between the two agents. Therefore, for an utilitarian, indifference curves for the distribution of profits between the two agents should be straight lines perpendicular to the diagonal line observed at 45 degrees on the x-axis represented in Figure 8.

The Difference Principle

John Rawls proposed one of the most notorious theories of justice of the 20th century. According to this theory there are two principles that apply to the basic structure of society. While the first principle refers to the conception and ensuring basic freedoms of individuals, the latter refers to the social and economic inequalities between them. On the first principle Rawls suggests that the basic freedoms of individuals should be equal; every individual should have the same basic rights. The second principle, called The Difference Principle, suggests a way to compare the social and economic inequalities of the basic structure of society. Assuming an institutional framework that guarantees equal freedom for all individuals and equal opportunities for all, the best expectations for those who occupy top positions are supposed fair if and only if they form part of a scheme which improves the expectations of the members of society experiencing greater disadvantage. The intuitive idea is that social order does not allow those in a better situation improve their actual condition, unless this creates a positive effect to the disadvantaged individuals too.

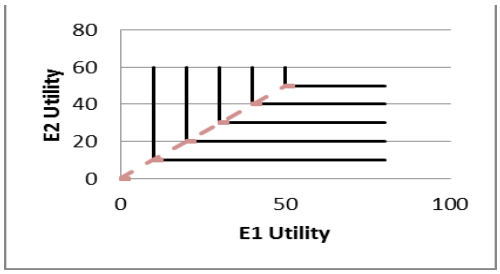

Figure 9. The Difference Principle

The Difference Principle implies that when having two people with different wealth status, unless there is a distribution to improve the situation of the two, a more equal distribution is preferable. According to this principle, indifference curves take the form shown in Figure 9. Each indifference curve consists of two straight lines, one vertical and one horizontal intersecting at right angles on a straight line (dotted here) rising from the origin 45 degrees above the abscissa. Note that these indifference curves assume that no

matter how much we improve the situation of an individual, there is no gain unless the other individual also has a profit.

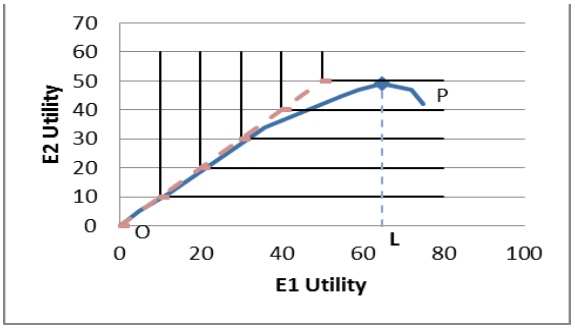

Figure 10. The Difference Principle and Contribution Curve

Comparing Figure 9 and Figure 10, in the latter has been added a "contribution curve" OP. The point O represents the initial state in which all social primary goods are distributed equally. We assume that between two individuals E1 and E2, E1 is always in a better position than E2. Therefore, the contribution curve representing the distribution between E1 and E2 will always be below the straight line inclined at 45 degrees above the abscissa. A point on this curve represents the utility of E2 relative to E1, and since we have assumed that E1 will always be in a better position than E2, it is only necessary to represent those portions of the indifference curves that are below the straight line inclined at 45 degrees. Clearly, the Difference Principle is satisfied only when the OP curve is tangent to the highest indifference curve that it can touch. In Figure 10 this occurs at the point L.

Several of the problems faced by students throughout the experiment led them to choose between solutions involving the Difference Principle and others that did not. Understanding this principle will be important later. In the same way, many of the problems faced in the experiment implied other classical solutions to distribution problems involving efficient solutions that fitted to different principles of justice. These are described in the following section.

Justice

Equity, equality and need

These three concepts of distributive justice can guide the behavior of individuals (Deutsch, 1975). The concept of need indicates a form of proportional distribution to individual needs. Equity refers to the distribution of goods, services or intangible values proportional to the merit of each individual. Equality denotes a distribution in which each person is entitled to the same amount.

Justice in Game Theory

Furthermore, since the experiment was conducted in a course in which the students should face decisions with multiple agents who must select decisions in the field of game theory, the development of competition in ethical responsibility also took this field into account. In this case students faced a situation where they had to choose in their opinion

which was the best solution among several that included the maximization of the sum of individual earnings, Nash solution, the maximin solution and the Maimonides solution. The students knew that these solutions had been proposed by prestigious people, like the Nobel Prize winners Robert Aumann and John Nash, and that none of the solutions was better in every way than the other. Additionally they were aware that these solutions implied different balances between efficiency and justice. We often assume that people always seek to maximize their utility in all labor relations and all interactive game character. However, research has shown that we cannot always assume this.

TOOLS AND MATERIALS

Student participation described in this research occurred in three stages of the course. At the beginning, students received a survey in which five basic problems were presented and they had to take justified decisions about them. Problems presented information using different tools, such as tables and figures, involving different levels of complexity, contexts and the opportunity of choosing between different solution criteria. For example, Table 1 presents a problem in which students had to choose the best or more adequate option for negotiation between two agents, who had different levels of richness previous to the negotiation, based on their preference criteria such as The Difference Principle, maximizing the sum of profits, etc. Figure 11 shows a different representation of a similar problem in which students had to take justified decisions about the negotiation presented.

Table 1. Question 1 options

Result	Earnings for E1	Earnings for E2
A	30	31
B	40	37
C	55	45
D	59	47
E	65	49
F	72	47
G	75	42

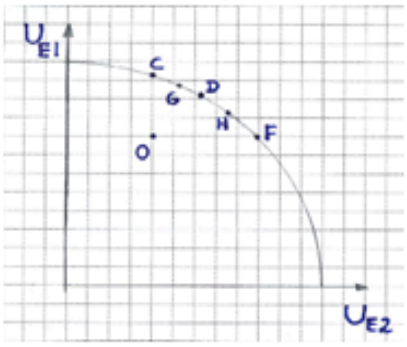

Figure 11. Question 3 options

In the final stage of the course, the same survey was handed to students, implying that the contents of the course were covered and may have influenced their responses. Also, a single reflection on the problems was proposed, along with a group reflection. During the last week of the course, students were involved in a third exercise that took advantage of the previous reflection, but also added specific topics of game theory, which were first addressed individually and then in groups under the guidance of critical systems theory that encouraged a group critical reflection on the issues of justice and efficiency (see Ulrich, 1982). Over the last problems, students explored and built solutions based on the Nash equilibrium, the maximin solution, the Maimonides´ solution proposed by the Nobel Prize Aumann, and others contrasted with solutions based on criteria such as maximizing the sum of profits and by principles on which the students had already shown their preferences in the first surveys.

RESULTS

Given the extent of the survey and of the present document, it is not possible to go into the details of each questions' results. The quantitative analysis presents the results obtained in three of the problems of the survey, before and after taking the course. These problems were selected consciously, so they include a general picture of the students' reflections among their decisions. They present the students' main considerations, ideas and concepts used to intervene in negotiations.

Quantitative Analysis

As mentioned before, the survey used figures and tables to present the negotiation situation. This influenced the students decisions, so their inclinations could be predicted by the type of question asked. When the problem included tables to present the negotiation, students tended to select distant efficient solutions. On the other hand, when the problem included figures, a higher percentage of students usually selected efficient solutions. To illustrate this, questions one and three are analyzed below.

Both were introduced in the previous section by presenting Table 1 and Figure 11, which were used to represent the negotiation situation in questions one and three of the survey respectively. In the first question, students had to select the most appropriate option among earnings in a two agent negotiation who had different levels of wealth. As observed in Figure 12, before taking the course, in question 1 options E and F were preferred, each one in a 36% of the students. This means that at the beginning they tended to select a situation where the agent with less wealth benefited the most or where the sum of profits among agents was higher. This predilection did not vary significantly in the second survey, were option E remained with a 36% of the class, but option F captured a higher percentage of the course (48%) and became the most popular choice.

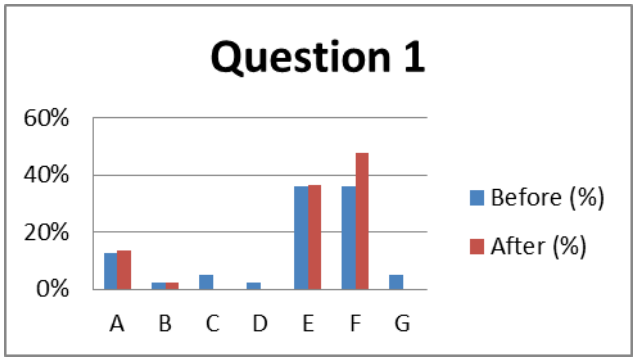

Figure 12. Question 1 frequencies.

On the other hand, when analyzing Figure 13 and the decisions made by the students refering to its best negotiation solution, the figure showed that the students tended to choose options in the efficient frontier. In this case, there were also two agents involved with different levels of wealth, but the difference was stated explicitly when refering to point O of the chart. However, the decision depended on the way students limited and interpreted the chart. When observed as a whole, it appears that option H besides being efficient was the most equitative choice. Now, when the context of the graph was limited

and axes were drawn at the point O, the most equitative option seemed to be D. The last alternative was the most common selection amog students, 31% and 74% of them after and before the course respectively. This means that most of the students took into account the initial conditions of each agent (point O), and starting from this circumstances, mainly based their decisions on the equity concept.

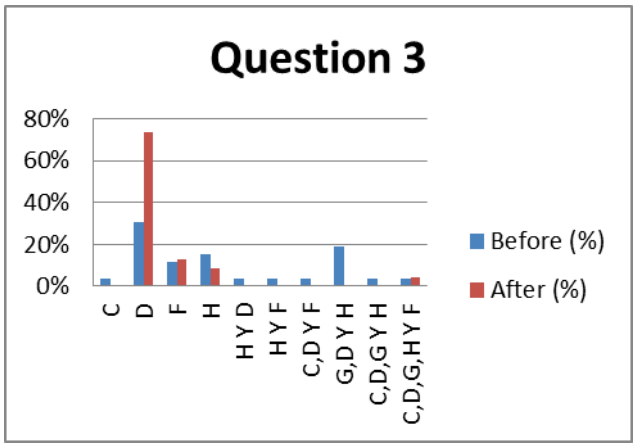

Figure 13. Question 3 frequencies.

The results obtained in question one of the survey were shown in Figure 12, making evident that in general both before and after taking the course , 36% of the students tended to select answers distant from an efficient criterion. Although after taking the course 48% of the students selected an option related to maximizing the utilities for both of the agents. On the other hand, as in the first question, the fifth question presented a situation between two agents with different levels of wealth, where students were asked to select the most appropriate negotiation results. On this question, both before and after taking the course, 35 % and 41 % of students respectively (Figure 14) selected answers that as in the first question were distant from an efficient approach and rather they were associated with maximizing the sum of the utilities of both agents (option G).

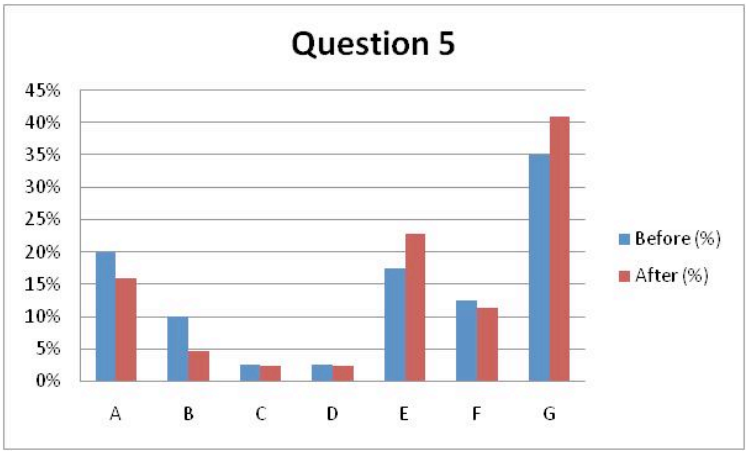

Figure 14. Question 5 frequencies.

However , differences in the percentage distribution in the selections of both questions were seen as in the first question after taking the course 36% of the students selected the answer that provided higher profits for the least wealthy investor, while in the fifth question, this value corresponded to 23% .

Table 2. Second activity frequencies.

Maximin	15
Max(x+y)	4
Maimónides	4
Nash	10

On the other hand, in the second part of the activity, at the end of the course the students were asked to choose between four theories proposed by different authors. According to the results presented in Table 2, 45% of the students selected the Maximin option related to the maximization of the profit given to the agent who could receive the least amount of gaining among the participants of the negotiation. The least chosen options where the maximization of the sum of the utilities and the solution of Maimonides with a 12% respectively. It is important to see the difference on the results presented in the survey explained above and the one presented in Table 1, it seems that the explanation from these four theories generate a bias in the selection of the students.

Qualitative Analysis

Based on the quantitative analysis presented above, a quantitative analysis takes place using System Thinking elements related to boundary judgments and critique along with biases concepts.

Boundary selection

During the experiment students choose the system boundaries in different ways. For instance, when they had to deal with the problem with the information that is synthesized in Figure 11, some of them (Group A) put the system boundaries to the northeast of the origin of the Cartesian coordinate system represented in the figure, while others (Group B) set the system boundaries to the northeast of point *O*. Those who set the system boundaries to the northeast of the origin of the Cartesian coordinate system regarded the initial wealth of the parties involved in the problem to be relevant to solve the problem. Therefore, they were prone to select point F as their preferred solution, for point F represented a solution which they considered more egalitarian and which contributed to balance the pre-existing differences among the parties involved. On the other hand, the members of Group B usually preferred point D with similar arguments (for instance, they argue that point D represented an egalitarian solution). As it is represented in Figure 4, members from

groups A and B chose different primary boundaries. Member of Group A consider the initial wealth of the individuals to be within the system boundaries, while members of Group B, marginalised the initial wealth of the parties. Conflicting ethics arise from the two alternative boundaries (see Figure 4) and when members of Group A had to dialogue with members of Group B about their preferred options, these conflicting ethics played an important role. The two competing discourses were usually linked in the dialogue to much wider struggles which could be frequently linked to wider social discourses (for instance, discourses about liberalisms, socialism, Christianism, etc.). By understanding how ethical choices are linked to the selection of boundaries (see Figure 1) it was easier for the students to grasp the source of their differences.

When students came to discuss their answers to the questions the selection of system boundaries was an important issue. For instance, when confronted with some problems some students did not consider issues that other students regarded as fundamental. For instance, one of these issues was how much the parties initially contributed to the common business or project. While for some this issue was fundamental (within the primary boundary), others preferred to marginalise this issue (it was part of the marginalised elements), and the rest do not even think about it (it was not considered pertinent) (see Figure 2). By clarifying where the boundaries are, students could develop a better and more picture of the situation that can help them develop more informed and critical arguments about the situation.

The selection of boundaries depended on a multiplicity of factors such as the background of the individuals, their emotions, their interests, their human needs, their moral frameworks, their cognitive processes (as will be illustrated later), etc.

Bias

We might expect students to take rational decisions when they dealt with the problems and when they participated in the discussions we promoted among them. However, they may have been prey of some "cognitive illusions". These illusions did not seem to be capricious. When students answered the questions we gave them, they resorted to heuristics as part of the tools they used to take decisions. These heuristics could be described as simplifying strategies used to find adequate, though frequently imperfect, answers to problems (Kahneman, 2011). These heuristics may implicitly direct our judgement without being chosen. Heuristics are implemented by what Stanovich and West (2000) have called System 1, a system of the mind that operates automatically, unconsciously, and rapidly to take decisions. System 1 uses heuristic processing and is undemanding of computational ability. System 1 stands in contrast to System 2. The latter involves analytical intelligence, higher levels of computational capacity, as well as more mental concentration and consciousness. Because heuristics are imperfect and they are not frequently followed by rigorous thought, they may lead us to biases. In other words, our students were bounded in their rationality by judgemental heuristics. Individuals use a

variety of these judgemental heuristics. In this paper we will describe how two of them affected the decisions of students.

The first heuristic that we will explore is the availability heuristic. We will illustrate its operation by making reference to Table 1 and Figure 11. Table 1 made it easy for students to calculate which option was associated with the higher collective sum. By looking at the table they could calculate the sum of the earnings of the two parties in a quick and easy way. In this case the majority of students selected the option that maximised the higher sum (option F, that was selected by 48% of the interviewees by the end of the course). On the other hand, in the problem associated with Figure 11 it was more difficult to establish which option was associated with the higher collective sum. In fact, this was option F, which was selected only by 12% of the students. In this case option D was preferred by a higher percentage of students (72%). Our hypothesis is that even if we have a preferred criterion (e.g., maximise the sum of utilities), we tend to apply it with a higher probability when it is cognitively easy to apply it compared to those cases where this criterion is not easy to apply or calculate. This type of availability heuristic might be called availability *to calculation*. When an idea "comes to mind" more easily and readily than others, we are more likely to prefer it. How easy it is to calculate something may bias our judgements. As Kahneman (2011) has stated, System 2 is frequently lazy in many people who tend to answer questions with the first idea that comes to mind, an idea that is produced by System 1.

On the other hand we also observed the presence of the "framing" effect (Hastie and Dawes, 2001) in the decisions students made. Changes of preferences might be caused by variations in the way the same problem is presented. As was illustrated in the previous section, when students faced problems in which the results were given quantitatively in tables, they showed a tendency to prefer solutions that maximise the sum of the earnings for the two parties. However, when students saw problems in the forms of graphs, they tended to favour other types of solutions, such as the ones that result from looking for the maximin or the Nash solution. For instance, in the problem represented in Figure Y only 12% of the students preferred to maximise (x+y) while 30% of the students preferred the Nash solution and 45% preferred the maximin solution.

People rely frequently on cognitive strategies that are cognitively economical. These strategies tend to be robust in changing situations, when there is incomplete information, and when the mind confronts distractions (Hastie and Dawes, 2001). However, many of these strategies cause biases under some conditions. In our case, we argue that these cognitive strategies may cause biases in moral reflection.

DISCUSSION

As a result of the previous experiment, we can conclude that the students boundary judgements come into conflict as they base their decisions on different ethical assumptions creating primary and secondary boundaries. The presentation format of the information plays an important role when selecting solutions, when selecting efficient solutions the main criterion is related to the justice definition based on equity and the

consideration of the initial conditions of the situation. On the other hand, cognitive strategies may cause biases in moral reflexion as it is based primarily on the availability of the information that is considered in the decision making process.

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