Designing an Operations Research Course Under Active Learning Strategies

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Introduction

In **Figure 1** a general structure of this paper can be observed. There are two important reference points: Icesi University as an institution and the context in which this document develops and our interpretation of and commitment to Active Learning concepts.

From there, we will get to outline activities and resources that we consider useful for an O.R. class in this or another university.

Icesi University as an instructional body is convinced that Active Learning is useful for its students' formative process. This, because Active Learning works to educate people that are not mere collectors of memorized information but rather people capable of thinking, acting, thinking critically and move on to a path of professional continued self learning. That is why the premise of *"do not give the fish"* (which would be analogous to providing memorized content) but *"teach how to fish"* (which would equal the development of abilities to use information and keep on learning) is perfectly accepted in this institution.

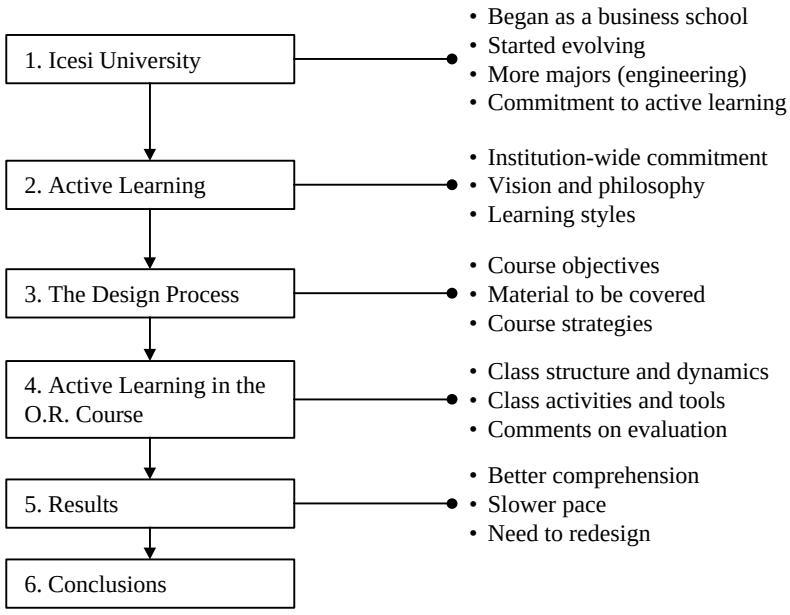

Figure 1: General structure of this document.

1. Icesi University

Icesi University was founded 22 years ago as a private small business school. It offered initially an undergraduate program in Business Administration. Five years after that the undergraduate program in Computer Engineering began to be offered. Also, the school was offering an assortment of graduate programs in Business-related subjects.

These two undergraduate programs had separate Operations Research classes, but in 1996 and as a result of a review in their curricula, it was decided that they would take the same class in mixed classrooms.

The school then decided to broaden its academic programs offer and apply for the University Status. In this manner began the undergraduate programs in Industrial Engineering (1997); Industrial Design, Economics, Telematics Engineering (1998); Law (1999) and Accounting (2000).

The University has a philosophy of keeping a core group of classes common to most of the majors. All the liberal arts classes, mathematics, basic sciences and humanities are common to most of the undergrads. It is our belief that in this fashion they will benefit from the interaction with different minded students, with a different set of goals and interests, and that this also will benefit them in the future, enhancing their ability to interact within a company with many different professionals speaking different "languages".

In this framework, the Operations Research class is being offered today to Business, Industrial Engineering, Computer Engineering and Telecommunications Engineering majors. It is obvious that the needs of these professionals are profoundly different, yet we believe that they're not irreconcilable and can even be complementary.

2. Active Learning

Since 1997, Icesi University has made an institution-wide commitment to change the basic philosophy of the learning process[1]. In particular, a group of concepts known as "Active Learning" was adopted for all the university. Our size (1800 + undergraduate students in all) allows for a closer communication between administrators and faculty, so an intensive series of training workshops was devised for the instructors to begin gaining their attention and commitment.

Our fundamental premise can be stated as: ***"Nobody can teach anybody, each individual builds his/her own knowledge"***. As a consequence, the teacher's role changes from somebody who ***teaches*** to somebody who ***helps the student to learn***. The University is no longer a place of ***instruction*** to become a place for ***studying and learning***.

The work environment for the graduates changes quickly, making technical information obsolete in a short time. Thus the most important thing that a student can learn in his/her university years is ***how to continue learning.***

This raises some important questions, like:

a. In this framework, what must be the teacher's role? The teacher should be a *designer and administrator of learning experiences*. He/she can't pretend to convey all the contents to the students, he should rather design a course, its activities and tools for all the experiences in the class in a manner that all those experiences are of maximum benefit for the students. He must design situations to engage the students in *doing things* and *thinking about the things they're doing*.
b. What must be the students' role? The student must be committed to his/her learning process. This implies a thorough and intentional preparation of the material that will be covered in class, so the concepts studied can be transformed into knowledge. The student must come to class ready to solve doubts, to learn from everybody else's interventions, to participate in the (individual and group) activities planned by the instructor and, through all these processes, to construct his/her own knowledge.
c. All the students are different. How to make the learning process benefit all of them? A vital concept in this area is the different ***Learning Styles,*** which will be discussed next.

Learning Styles: Different authors have proposed a variety of learning styles models (and their application to engineering education); among the most popular in recent times we can mention The Myers-Briggs Type Indicator, Kolb's Learning Style Model, The Herrmann Brain Dominance Instrument and The Felder-Silverman Learning Style Model. At Icesi University we have used The Felder-Silverman Learning Style Model[2, 3], which presents five important "dimensions" for the learning process and characterizes each person's preferences in every one of them. These dimensions are:

- **What types of information are preferred?** A ***Sensing Learner*** is an individual who prefers to perceive through his senses; an ***Intuitive Learner*** prefers indirect perception through speculation, intuition and personal impressions.
- **How is this information perceived more effectively?** ***Visual Learner*** when drawings, pictures, diagrams and demonstrations are favored; ***Verbal Learner*** when sounds and words (and their written representations) are preferred.
- **What is the organization of the information preferred?** If prefers to start from applications and phenomena to infer fundamental principles from them is an ***Inductive Learner***; if, on the other hand, prefers to know the technical foundations, the basic concepts and then derive the applications and uses is a ***Deductive Learner.***
- **How is the information processed?** An ***Active Learner*** likes to take part in physical activities and group discussions, a ***Reflective Learner*** likes to have time to himself to reflect and elaborate individually.
- **How does the person move towards the understanding of the subject?** In a continuous, linear fashion (***Sequential Learner***) or in discrete, "holistic" jumps (***Global Learner***).

Generally speaking, it has been found that students in specific fields tend to be more concentrated in one of the sides of each dimension (in a study conducted by Hipólito González, Ph.D., the Senior Academic Advisor of the University with freshmen, he found that they were mostly *Active, Sensing, Visual* and *Sequential Learners*. The dimension of "Information Organization" was not assessed at that time.)

However, in a classroom there will always be a mixture of people who find themselves related to both ends of every dimension, which indicates that the activities designed by the instructor must address every type of student. This also makes indispensable that the instructor becomes aware of his own styles and preferences, because those are usually favored by him, to accommodate a more varied mixture of styles in the design of the class.

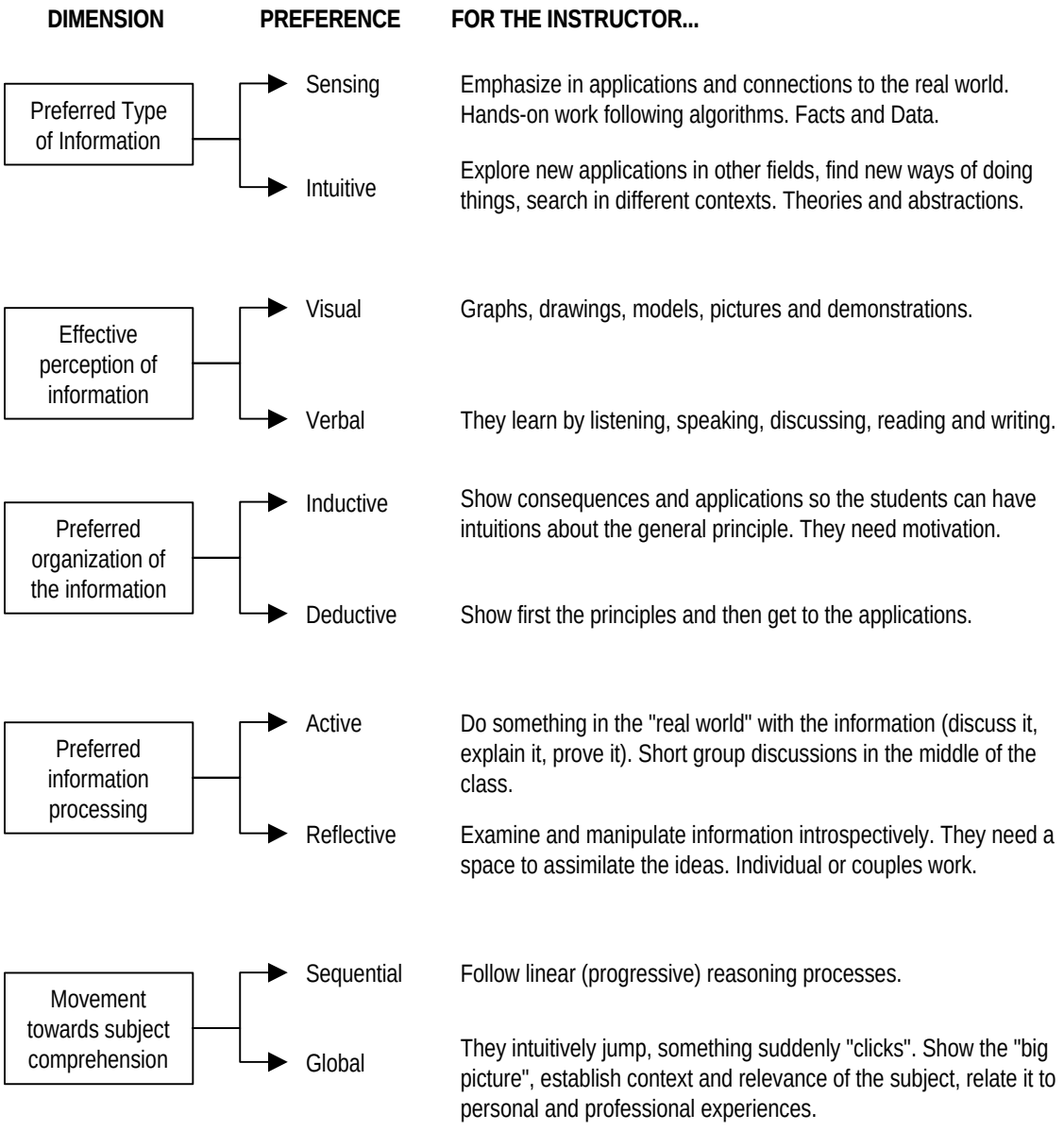

Figure 2: Comments on learning styles for the instructor.

3. The Design Process

Here the generic Design Process will be outlined, making specific references afterwards to the course treated in this paper. Figure 3 shows the generic Design Process.

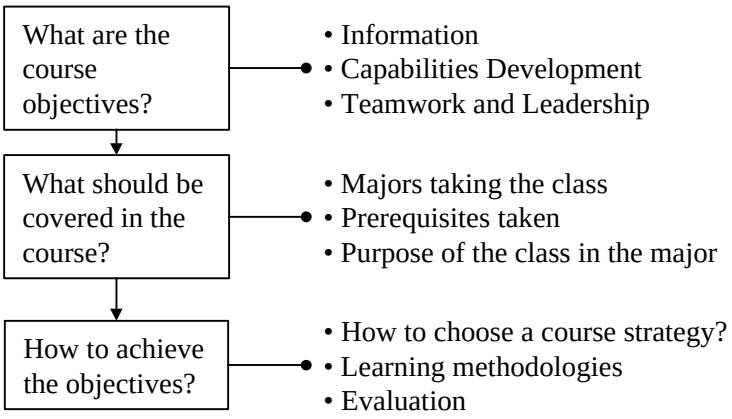

Figure 3: Generic Design Process

The Design Process for a course involves several steps that must answer some very basic questions:

- *What are the objectives of the course?* There are a lot of different things that could be defined as objectives for a course. They could vary a great deal but also could be applicable for different settings. For instance, a course could be directed mainly to provide (current, updated) information. A different focus would be to have as a main goal the development of very specific capabilities, not to acquire contents. Another possibility is to have a project-based class which goal was to learn teamwork and leadership skills
- *What should be covered in this course?* What's covered, its order and sequence depends on several variables like majors taking the class, prerequisites or previous classes taken by the students, and mainly the general purpose of the class for each major.
- *How to achieve the course objectives?* There are different class strategies: Project-based classes, lecture-based, discussion-based, based on case studies, cooperative learning and active learning. Each of them has its own characteristics and applications, with different demands for the instructor and the student, and expected results. Also, this includes selecting and designing evaluation moments and tools that are congruent with the overall chosen strategy.

These steps could be treated in more detail, but curricular design is not the main focus of this paper. Here we will discuss the application of these generic steps to the specific course of Operations Research at Icesi University:

- *What are the course objectives?* The main goals of this class are to develop modeling, problem formulation and solving abilities, and the awareness that there exist a lot of OR techniques that could be useful for them in other settings (information).
- *What should be covered in the class?* This class will be taken by Business majors, as well as all Engineering majors (Industrial, Computer, Telematics) in mixed classrooms. In general,

what need to get from this class are the objectives stated in the previous point (those were defined through a series of meetings when consensus about them was reached). So, it was decided that for this course the topics covered would be:

- Linear Programming: Modeling, Applications, Solution Techniques, Algorithms, Computer Packages, Sensitivity and Dual Analysis, Special Algorithms. (50% of the semester)
- Project Management and Control: PERT, CPM, Critical Chain (25% of the semester)
- Decision Processes: AHP (Analytical Hierarchy Process, 25% of the semester)

- *How to achieve the course objectives?* In section 2 (Active Learning) was specified clearly the institutional and personal commitment to Active Learning, as well as the reasons for adopting it as the main strategy. In section 4 (Active Learning in the O.R. Course) this will be discussed in greater detail.

4. Active Learning in the O.R. Course

This subject is the heart of this document. Its general structure can be observed in Figure 4.

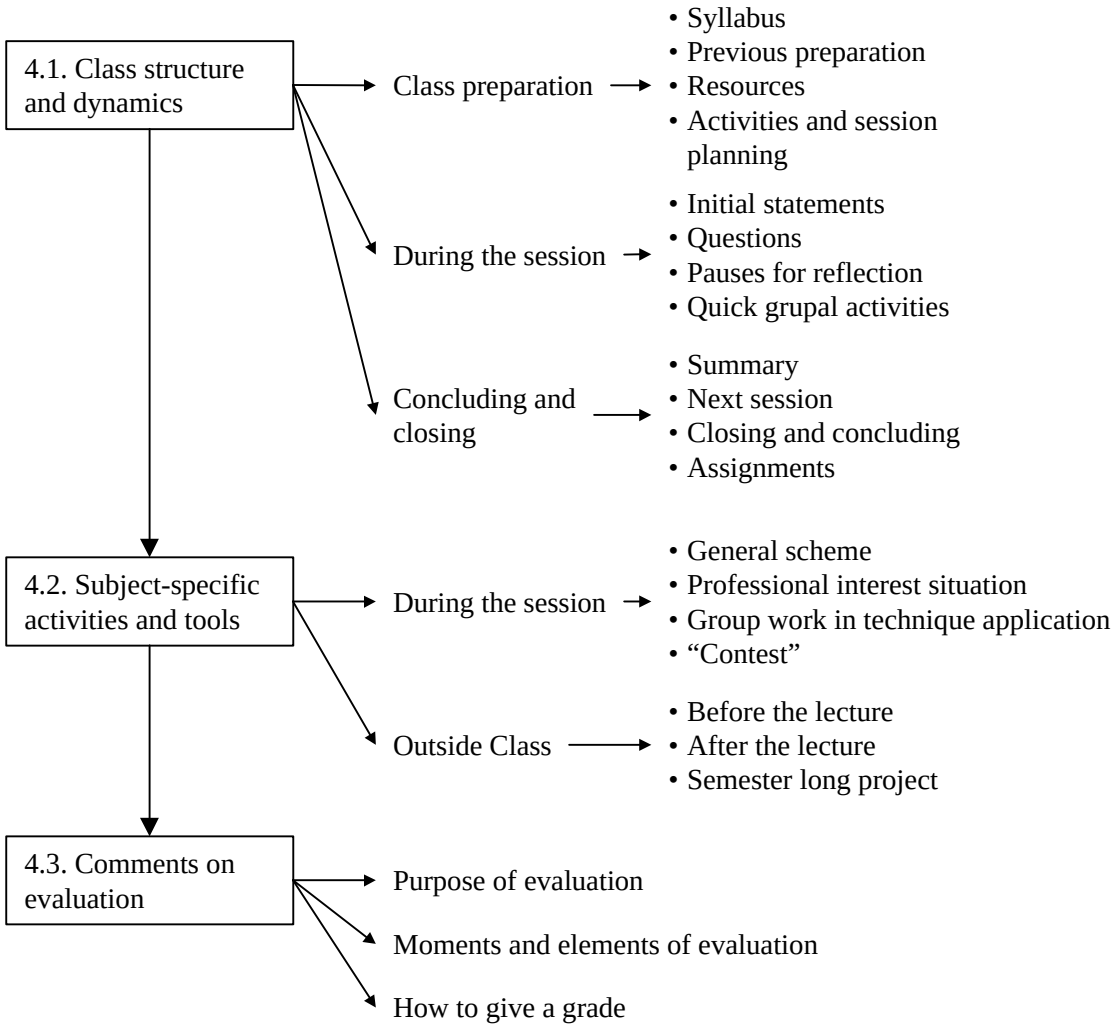

Figure 4: Structure of section 4

Annotations about the preferences in learning styles will be embedded in each of the subjects mentioned above to point out which of them are favored in each type of activity or exercise. The objective is not only providing experiences for all the different styles but also allowing students to practice learning styles different to those they are more comfortable with. In their work life they will not always be able to make the situation to conform to their preferences, so they also need to be able to work in different settings and styles.

4.1. Class Structure and Dynamics: Which steps and phases are required to apply the exposed principles in a class session are discussed here. Three important moments will be highlighted: *Preparation* of the class, class *execution* and *closing and concluding* in the classs.

Preparation of the Class: The class must be prepared by the instructor as well as by the students. The **first** issue is putting together the Class Syllabus. In this document you should find things like:

- Administrative information (Academic period, credit hours, instructors' names and contact information, majors offered to, prerequisites)
- Introduction: Context, professional relevance, connections to other subjects and classes (*sensing – global learners*).
- Course objectives (including applications: *sensing* and *intuitive learners*).
- Methodologies used to achieve the objectives.
- Contents to be covered.
- Evaluations (weight, criteria, moments).
- Bibliography (textbook and other reference material)

This syllabus should be handed out in the first class of the semester, even before if that is possible.

The **second** issue is the previous preparation and study of the material assigned for that session (this must be specified in the syllabus). In an active class, the student that has not prepared the material will benefit little from the session, which is designed to solve questions, show applications, clarify concepts and *do things* with the material studied, either individually or in groups. The importance of this preparation must be continuously stressed (especially at the beginning of the semester), though the development of the sessions should show them by itself that if they don't want to lose the group's pace they need to come to class with the material studied (*verbal-visual* depending on the textbook*, deductive, reflective, sequential*).

The **third** issue includes the preparation of all the audiovisual and auxiliary resources that the teacher will use (with his and the audience's interventions) for the session (*verbal* and *visual*).

Last, the planning of the class, tools and activities flow. Plan which activities will be used, which styles do they serve better and balance this styles and students mix. Good for *all the styles*.

Execution of the Class: As it has been said, the teacher's role is to guide his students in a manner that their learning processes is the best possible. Because of this, in the session itself the

teacher must provide context, background, goals and objectives, applications and connections with the subjects being discussed.

At the **beginning** of the session it is important to remind the class what was the previous discussion and what will be covered in this session.

Also, the discussion should be opened with the appropriate use of the right **questions,** searching the group for clues on how to manage the rest of the session and which should be the emphasis of the day. It is possible that the group requires a more detailed explanation of the material (*verbal, reflective, sequential),* or the materials are clear and what is needed is to go through examples, applications, ways of putting the material to use (*sensing* and *intuitive, visual* and *verbal, deductive, active, sequential*).

It is important to keep in mind that in some key moments, or after presenting explanations or clarifications, the instructor should provide short breaks so the students can think about what has been presented to them (*reflective).* It is also possible to ask quick questions to be answered promptly in groups of (at most) three, which gives them the opportunity to discuss and interact (*active*).

Usually textbooks present their contents starting from basic principles and formulations to derive applications (*deductive*), however, the student is left with the feeling that these principles were found by the researchers in a simple and orderly manner. It is important then to present background, associated phenomena, problems that could be solved in a way that students can develop an intuition for what's next, trying to follow some of the paths that the authors and researchers had to follow in their time to go from the specific to the general, from what you can observe to the underlying principle (*inductive*).

Depending on the state of the subject covered, the instructor could plan a session based on a lecture by him and short discussions between the students, or including longer tasks that the students have to complete in the class time to be turned in. In groups (*active*), take the concepts and techniques explained and follow their application to a specific problem (*sensing, verbal, deductive, active, sequential*), or to allow teams to search for new applications in different fields (*intuitive, verbal, active, global*).

Concluding and closing: Each session must be like a chapter in a television series. You come from a previous state of things and have to keep some continuity, so each chapter must have "scenes from previous chapters", a plot and development on its own, the proposition of important issues and questions to be solved and "scenes from the next chapter". Each chapter has to be a part of a whole thing (the course), but it also must have unity, autonomy and goals and tasks on its own (keeping the due context). The beginning and execution of the class have already been discussed; here we will comment about closing the session.

At the last part of a class session there exists an important factor, namely **time**. Time is tricky and elusive, you have to plan for closing time and stop the students' work ahead. Active work in class generates its own inertia and in consequence it is impossible to get it to a grinding halt. Students want the chance to finish what they have begun, whether they need to turn it in or to be

ready for the closing discussion. So, you have to warn them in advance so they can focus on closing their internal arguments, achieve some consensus, "put the cherry on top" of their work.

Once the space and attention for the closing discussion have been generated, the students' participation in concluding must be called for (*active*), and the instructor can summarize conclusions in the board, writing them down (*verbal*) or connecting them in some form of chart or diagram (*visual*).

Besides, in this generation of conclusions the subject is "hot", the students are interested to see if what they did was "ok" and they are paying attention because they want to see where all this work finally takes them. This is a good time to ask questions for immediate answers (*active*) or questions that will be assigned as homework. In particular, questions can be directed to imagine applications in other fields (*reflective, intuitive*) and to have the students find connections with their own experiences and other subjects already treated or to be treated in the future (*global*).

Finally, the instructor must assign homework for the next class, remind the students of the material they must prepare (this must also be in the syllabus, so they can prepare on their own (*active* and *reflective*) and briefly outline what's going to happen in the next class in terms of the connection between the material covered in this session and the material to be covered in the following one (*global*).

4.2. Subject-specific Activities and Tools: Here we will discuss some tools, activities, resources and assignments that can be used for this O.R. course. In addition, for each item we will remind the learning styles more favored by it.

In particular, we will take a look at activities to be used *during and outside the class session*.

During the Class Session: The presentation of the topics on O.R. classes tends to follow a pattern slightly different from what's common in more "basic science" courses. In our context, O.R. is a field oriented to solve problems and, at the undergraduate level (in our university), the students are more interested in usefulness and practicality than mathematical derivations and new algorithms (which, of course, is different to the interest that a graduate student in Industrial Engineering or O.R. might have).

Because if this, it makes sense that the student first faces a "problem" or "situation" that will likely arise in their professional life (also, making important to look for situations that appeal the different undergraduate majors we have together). Then you can characterize these types of problems ("*this is called a transportation problem and we can distinguish it because...*"), to move onto the presentation of the concepts and techniques to be introduced (trying to keep connection to the problem) from a mathematical as well as practical and operational point of view. Finally, some practice exercises can be tackled and different applications of the technique can be explored (Figure 5).

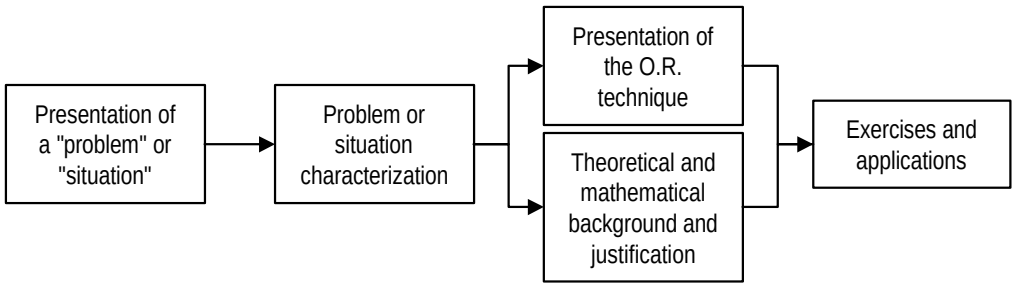

Figure 5: General scheme for the introduction to a new subject

According to this, a **first** type of activities would be those in which the student faces a situation that according to his professional preferences could be a real one in his work field (*sensing, inductive, active, global*). For example, Industrial Engineering students could tackle problems where they have a limited supply of resources to transform them into several different products with their own per unit resources consumption and revenue generation, to decide how many units of each reference must be produced to maximize profits (***product mix problem***). For example, for a Business Major, a situation with some surplus budget to be invested and an assortment of investment opportunities with different risks, taxes and returns (***portfolio problem***). The objective could be to achieve maximum profits on a portfolio with an average risk level under certain limit.

The first time you bring such a problem to class, you can ask the students to try and solve it in whatever fashion they want, working in groups (and individually if they prefer) and using anything they remember from previous courses or bringing any books they want into the picture. This is useful to collect from them what insights and intuitions guided them and use those to introduce the technique or algorithm for the subject. Generally speaking, some students will have some very good intuitions and that will give them all a sense of connection between their experience ("real life") and the techniques discussed (*global, active*).

It's possible that, before the lecture or instructor's explanation, the students (if they have prepared the class material well) can relate the problem to some characterization and solution technique on their own (this would be great anytime). However, if this happens you can use it to recognize their achievement and introduce them to a more challenging setting or a different context, so they can start getting a feeling for the internal structure of the problem and its characteristics, and then they can apply this principles in the search for the solution technique-algorithm (*intuitive, deductive, active*).

A **second** type of activities would have as objective that the students, using their individual study before class, solidify their concepts and principles before or after the instructor's intervention. For example, the class could be divided in small groups at the beginning of the session with the specific task of preparing a presentation for their classmates summarizing key concepts of a part of what they studied, its connections with the previous topics and the unclear issues and questions they have brought to class (*active, intuitive*). This activity achieves connection with previous sessions and also eases the feedback collection process for the instructor so he can reinforce the necessary subjects and provide more explanations and examples as required.

A **third** class of activities are directed to have the students clarify (through practice) the application of a particular algorithm or technique during the class (*sensing, active, sequential, deductive*), so the instructor has the occasion of guiding and correcting them. This is done better in small groups, so the students can interact and discuss among themselves (this interaction is a vital element of an active class, also an element that has not been possible to duplicate fully in self-instruction or distance learning). The instructor can then present different problems to the same groups or the same problem for the whole class, to solve it later or have a student come to the board to solve it for the whole group.

The **fourth** option is a good one once the subject has been discussed and worked and explained enough and what you're looking for is some positive reinforcement for the concepts and their applications. It consists in something like a "game show", in which the room is divided in teams and a question is launched (works better with questions that go beyond what's been covered or look for further applications or elaboration). The "winners" in each question can receive small prizes like snacks, mechanic pencils and so on.

The use of physical objects as prizes instead of bonus points for the final grade may seem unorthodox, but it makes sense since it is something visible that they can be proud of, not very valuable (in monetary terms) and also doesn't put in a disadvantaged position those students that do not react quickly to this type of questions, or those too shy to come forward with their answers. Also, it should be avoided that only one group gets all the answers (because they dare to speak first or they're better prepared for the game), maybe having a "special prize" or declaring them "out of contest", so the rest of the class does not lose the interest.

Outside the Class Session: As it has been mentioned in a couple of points before, for an active learning class to work it is necessary that the students come to the class with the material to be covered already studied. This can be hard to achieve fully, especially in those cases where there is no homogeneity in learning approaches in a certain school or university. Students will find great differences between the level of demand of an active and a non-active class, and this could also lead to claims that all the time devoted to this class is making them ignore partially the other classes.

Outside class there will be some work assigned for "before" and "after" a certain subject has been discussed in class.

Before explaining a certain subject, the instructor can ask the students to follow solved problems or examples (all the textbooks have them) and ask some questions to guide this study (*sensing, inductive, active, sequential*). It is also possible to assign problems to be solved (better done in groups, since this are new topics to them, they can achieve better understanding through group discussion), trying to choose something feasible to be solved with the examples and explanations the textbook provides.

After the presentation and doubt solution of a subject it's possible to assign more complex problems, for example in a case study format, in which it is not obvious a straightforward application of an algorithm or formula. If possible, these case studies should present a situation in which the students can decide what are the goals, how to organize the information, which

techniques to apply and how to use them and interpret the results (*sensing, intuitive, verbal, deductive, active, sequential* and *global*). Since it requires such a wide range of skills, these exercises are better discussed in groups, and if you can mix students from different majors, all the better. Case studies have been a traditional methodology for Business majors, but Engineers enjoy them and do well on them too.

A class of activities that takes place outside class but it is not after or before one subject in particular (rather **during the semester**) has been used in senior classes but not so much in classes with a strong mathematical focus. These activities are the application of a set of the acquired concepts and techniques to a real situation in a company. In this case, it can be assigned as a semester-long project that the students find a company willing to work with them and give them certain information, get acquainted with the company, get to know its processes and detect in which of them exist problems or opportunities that can be treated with O.R. techniques. The instructor has to provide continuous counseling and follow the progress of these projects, because the students can face unfamiliar situations like:

- It isn't obvious which processes can benefit from the application of O.R. techniques.
- It isn't obvious how to apply the right O.R. technique to a certain situation.
- Finally, it isn't simple to decide which information needs to be gathered and how to gather it.

This type of projects is more fruitful for the students if the project teams can be assembled with individuals of different learning styles. For example, *sensing learners* feel more comfortable with hands-on work, but *intuitives* can collaborate in the translation of what's been seen in class to make it useful in a company setting. *Visuals* and *verbals* will handle a wide range of the data provided by the company, and will also use different media to convey the information to the rest of the class.

These projects, given the opportunity of presenting them to the whole class at the end of the semester, have a huge variety of learning opportunities for people with all different learning styles.

Also, the instructor has to be aware that these projects will be very time-consuming for the students and themselves. The greater the expected benefit, the greater the efforts from both instructor and students.

4.2. Comments on evaluation: In the Active Learning model that is being currently implemented at Icesi University there is a question in the ongoing process of being solved: *"How do I tell my students that the learning model is changing if I'm still doing the same traditional evaluations? That's not congruent..."*

To achieve a better congruency level, we must taker a closer look to what's the expected goal of evaluation and how to achieve this in a way that's compatible with the principles of active learning.

The Senior Academic Advisor from Icesi University, Hipólito González, Ph.D., published in January 2001 a booklet called ***"The evaluation of the students in an active learning process"*** [4],

in which he summarizes all the information shared by faculty on departmental meetings about evaluation practices and then lays out guidelines for the instructor looking for congruency between active learning and his evaluation methods.

What follows next are a couple of segments paraphrased from this booklet, noting that several of the activities mentioned in points 4.1 and 4.2 are adequate to be used in the **moments of evaluation** that will be discussed next.

We have to start with the question: ***"What is the purpose of the evaluation?"*** Every academic can relate to the idea that evaluation should be done in order to verify if the student learned. However, in the active learning framework, this is a continuous process that needs the instructor as a guide and supporter. Thus, the purpose of evaluation is to **obtain information.**

This information should be used by the instructor to decide how to tackle the next steps of the learning process, and by the student to assess his situation regarding the learning objectives of the course.

This leads to the first big factor to take into account in evaluation: **Opportunity**. This information for the instructor and the student (feedback information) is useful if it is presented close to the moment of evaluation (in fact, in the recently modified Student's Book of Rules it is stated that the instructor has at most 10 days to return graded material). So, if a graded quiz or report is returned to the students when it is no longer relevant, the subject will be no longer fresh in his memory and it will only be clear that he failed in certain points, but it will be impossible to correct them and make them a permanent part of the body of knowledge being discussed.

It is then evident that evaluation should be **permanent**, meaning that it should serve the purpose of monitoring the learning process in its different moments: When a specific technique has been learned, when a particular subject is being closed, etc.

This is why the evaluation scheme used by many instructors of having only two midterms and a final exam is not congruent with active learning, because the evaluation of a certain subject is done **when there's nothing to do about it**, that it, when it's impossible to go back over the subject to correct deficiencies and problems.

A second critical question is ***"What should be the moments and elements of the evaluation?"*** As it has been discussed, to limit evaluation only to two or three written tests is insufficient, so in addition to midterms and finals it is suggested the use of pop quizzes, short written tests, essay writing, individual or group assignments and projects as they have been discussed in previous points of this document.

What's important in this point is to uphold the principle of opportunity, and to keep in mind that the elements of evaluation are also elements of learning, so they must be designed and managed taking into account the differences between the students and their learning styles and the balance between individual and group work.

The third key question is: ***"How to come up with a fair numerical evaluation at the end of the course?"*** The Academic Council of Icesi University decided that every course should be approved based in the individual component of the work. That is, if a student fails in a certain percentage of the evaluations that are individual, the group component will not be taken into account. The rationale behind this was that the University issues a Diploma that certifies to society at large that this **individual** (not a study group) has fulfilled all that's needed to call him a professional. In many occasions it happened that individuals passed courses based purely on group evaluations, allowing that students that did not fulfill personally the learning objectives to take cover in a good study group and pass.

This doesn't mean that in certain classes a certain group project is not eligible for having a large weight in the final grade, since it comes from a lot of work and continued effort and it is the best opportunity to integrate a lot of the concepts in a course.

Another way of making up the numerical grade is to assign a certain percentage of the final grade to specific midterms and exams. This is the most traditional way.

Yet another way is to offer recovery possibilities and bonus points. In courses where the subject is cumulative (that is, to be able to do something towards the end of the course you have to apply all the material covered thus far), or in cases where the end-of-semester evaluations are cumulative, it can be appropriate to allow students to make up at the end in some way for bad grades obtained at the beginning of the semester. In this way, a student with low midterm grades can put on some extra work and see this rewarded in the final grade. Also, this avoids that a student with low partial grades will lose his interest and drop the class.

Finally, the basic message regarding evaluation is that the elements and moments of evaluation are also moments of learning, and that the purpose of evaluation must be to obtain information that students and instructor can use in the improvement of the learning process. Having these two concepts in mind, instructors can be as creative in the design of evaluations as they are designing learning experiences for their classes.

5. Results

The processes and activities presented in this paper have been applied in the second semester of 2001 and the first semester of 2002 to actual courses of Operations Research at Icesi University. The main results can be grouped like this:

- *Better comprehension:* The abilities desired have been acquired more successfully than in previous semesters. Students have told their peers to enroll in this class and for the first semester of 2002 my class session filled up before the other OR classes. Also, since the evaluation scheme was redesigned to give better and faster feedback, the grades have been consistently better.
- *Slower pace:* To be able to cover a wider spectrum of activities in and out of the classroom it would be desirable to have more time. When students realize things by themselves this learning is better than the otherwise achieved, but also requires more time than a traditional

lecture. In consequence, at the last sections of the course time becomes more and more a concern and sacrifices have to be made in order to cover the whole syllabus.

- *Need to redesign:* As a consequence of the previous point, it has become a necessity to redesign this course, either to select certain portions in which active learning will be applied more thoroughly, or to spread the contents (adding some more subjects) in two semesters to be able to apply this active learning principles completely. This discussion is being given at the departmental and faculty levels right now.

6. Conclusions and Closing Remarks

It is important to emphasize that the introduction of strategies like Active Learning (especially when it is an explicit institution-wide commitment) forces us to think again about a lot of the traditional teaching practices and which could be their contribution to an active class and to the different learning styles the students have.

Also, it is necessary that the Department Heads on each academic area work with their faculty in the development of curricula that formally introduce these concepts to each of the courses. Each instructor should plan his activities and evaluations according to the guidelines developed in each Department.

Particularly, for a course like Operations Research it is very useful to diversify the focus and activities used in a class. To focus only in mathematical aspects or to abandon them altogether and present only chug-and-plug algorithms and recipes not only makes for an incomplete experience but also leaves some learning styles unattended.

Topics like: Possible applications in different contexts, extensions of the theories presented, creative uses of mathematical tools and "¿what if...?" exercises have not been very common for these type of classes, but they would obviously be excellent tools to get some students to understand better the subjects of discusion.

General frameworks as the one presented in this document could be useful for instructors in a wide range of university-level classes that want to use active learning strategies.

1. GONZALEZ, H. Cartilla Docente: El proyecto educativo de la Universidad Icesi y el Aprendizaje Activo, segunda edición. Universidad Icesi, January 2000.
2. FELDER, R.M.; SILVERMAN L.K. Learning and Teaching Styles in Engineering Education. ASEE Prism, Vol. 78 No. 7, 674-681, April 1988.
3. FELDER, R.M. Matters of Style. ASEE Prism, Vol. 6 No. 4, 18-23, December 1996.
4. GONZALEZ, H. Cartilla Docente: La evaluación de los estudiantes en un proceso de Aprendizaje Activo. Universidad Icesi, Januany 2001.

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